Tappi

THE JOURNAL OF THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

NOVEMBER 1960

VOLUME 43 • NUMBER 11

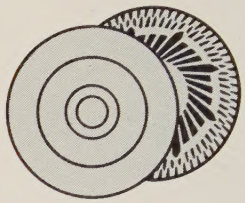
Push Button Precision and rugged construction identify the Raffinator Disc Refiner. The Raffinator is exclusive among disc refiners in having a hydraulic system for accurate, finger-tip control over disc positions at all times. Visual indicator shows plate settings magnified 80 times. Operates also on floating principle to allow for varying stock pressures.

Raffinator Disc Refiners are superbly engineered precision machines for all types of defibrating, and pump through or pressure refining at up to 20% consistency. Operates at speeds of 700-1000 rpm. All parts in contact with pulp stock are stainless steel. Refining discs are available in 24″, 36″, or 50″ diameters — in a variety of types and materials. Extra large shaft diameter prevents deflection in disc settings. Split shell facilitates precision plate adjustment and removal.

Introducing

THE

RAFFINATOR

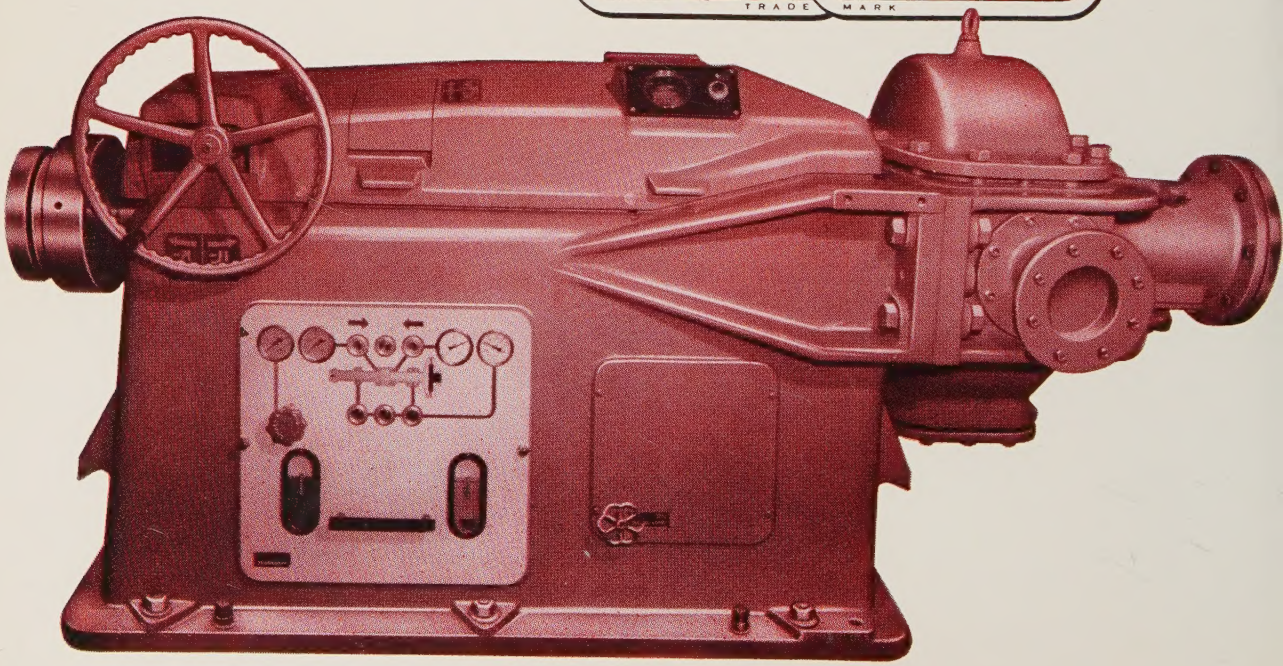


DISC REFINER

The Raffinator is delivered complete with electrical control panel. Even with its many unusual performance features, it is priced competitively with conventional disc refiners. Before selecting a disc refiner, it is wise to investigate the extraordinary advantages found in the Raffinator — already proved in over 600 mill installations.

Raffinator Disc Refiners, product of Swedish design and engineering, are now available in North America through Bolton-Emerson. For full information, contact *The Emerson Manufacturing Co., Division of John W. Bolton & Sons, Inc., Lawrence, Massachusetts.*

BOLTON EMERSON
TRADE MARK



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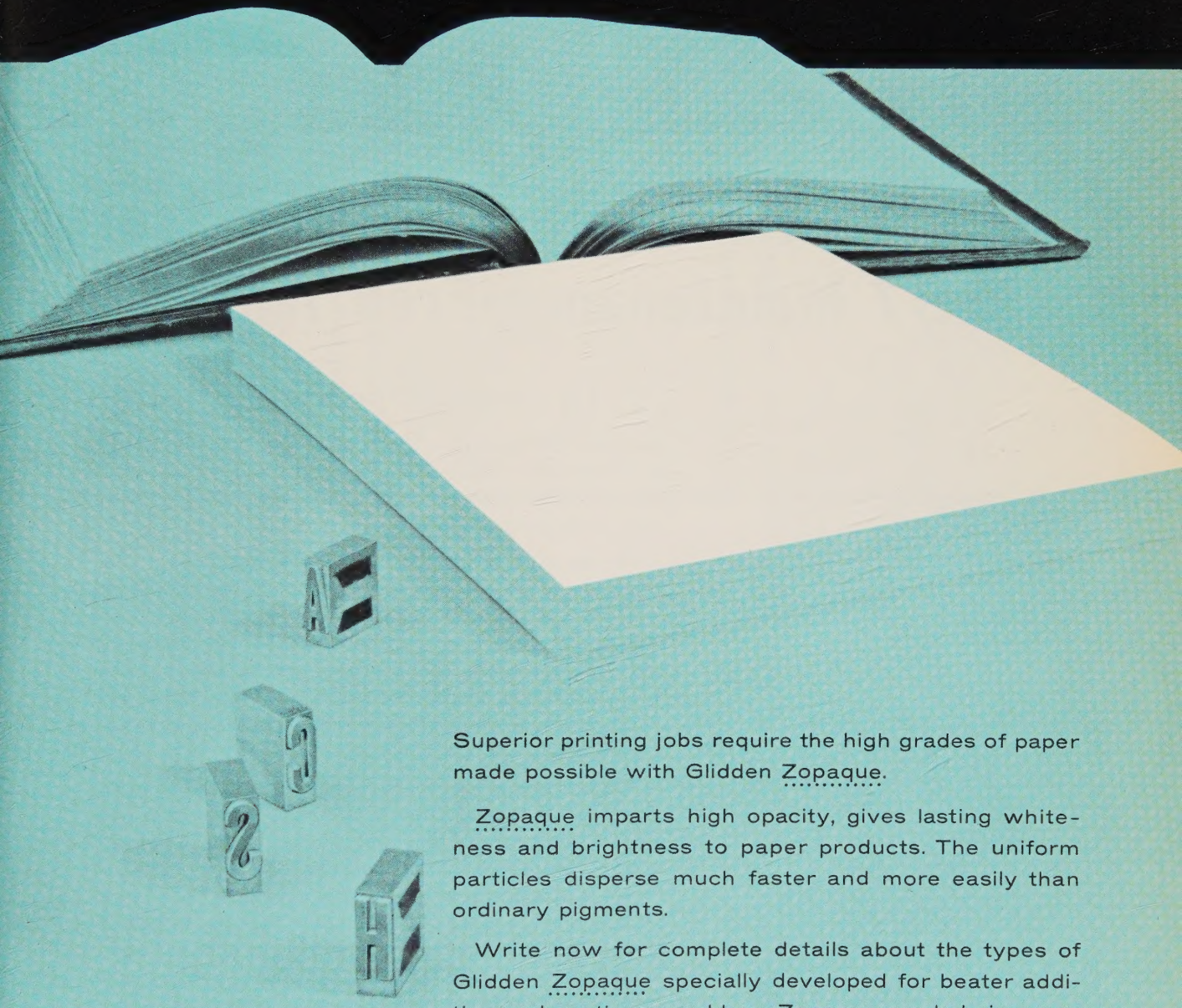

Superior printing jobs require the high grades of paper made possible with Glidden Zopaque.

Zopaque imparts high opacity, gives lasting whiteness and brightness to paper products. The uniform particles disperse much faster and more easily than ordinary pigments.

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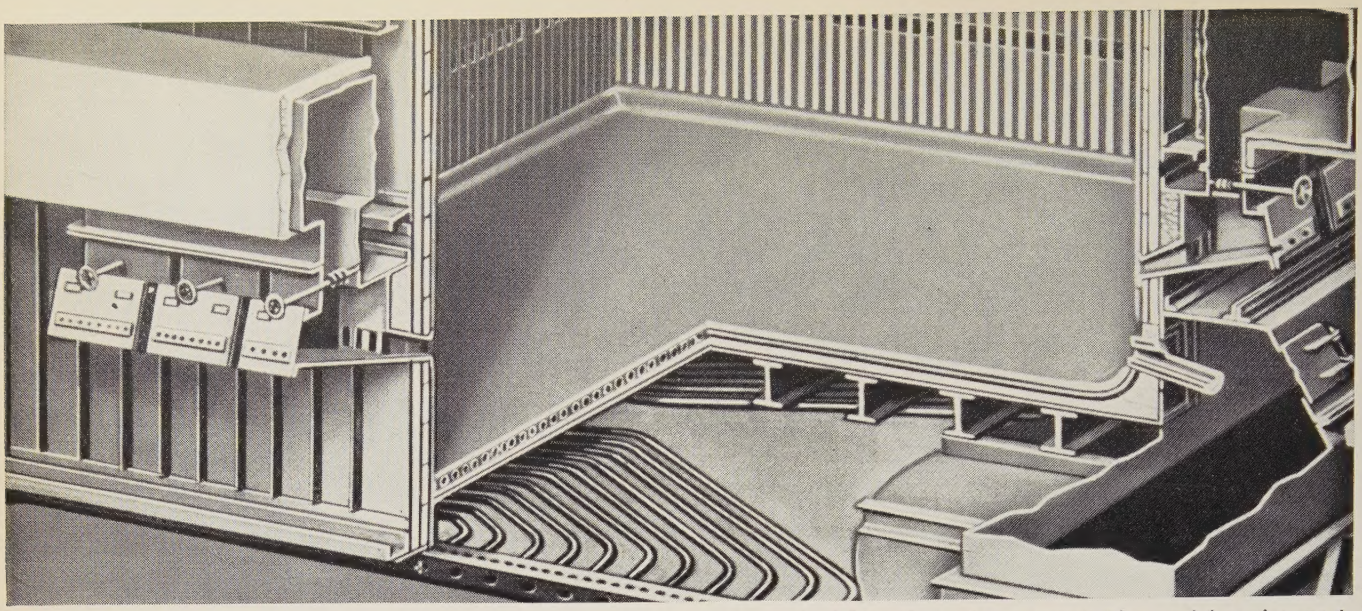
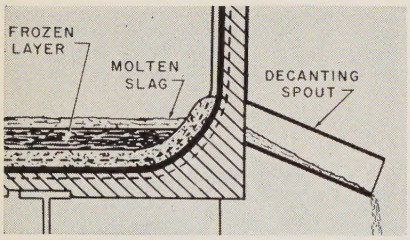
(This advertisement is printed on paper stock containing Glidden ZOPAQUE Titanium Dioxide.)

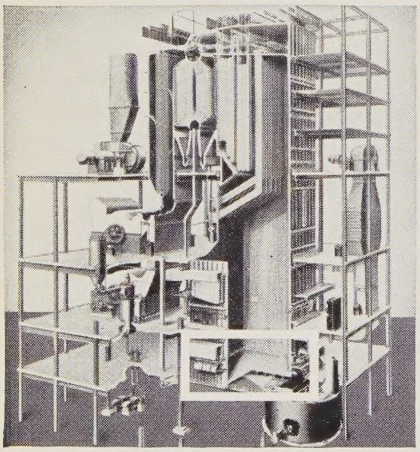


Cutaway view of the C-E hearth showing watercooled floor and decanting spout.

Watercooled Decanting Hearths Score 157 Maintenance-Free Years



Molten slag never touches furnace floor, preventing damage to hearth and contamination of slag by eroded refractory.



One of the latest C-E Chemical Recovery Units — an important part of the modern kraft pulp process. Note that slag from waterscreen and superheater can fall directly to hearth.

. . . in 50 C-E recovery units

Since the development of the watercooled decanting hearth by Combustion Engineering in 1951, 50 C-E Chemical Recovery Units have served an aggregate of 157 years *completely free from hearth maintenance.*

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The C-E Decanting Hearth eliminates a common cause of furnace shutdowns. Other C-E advances offer improved recovery unit control, flexibility and efficiency. And, because of the high availability experienced with modern C-E recovery units, pulp mills can now depend on one large-capacity unit in place of two smaller ones — with considerable savings in the cost of maintenance and operation. For interesting details, call the C-E office nearest you or contact the C-E Paper Mill Division in New York.

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C-269

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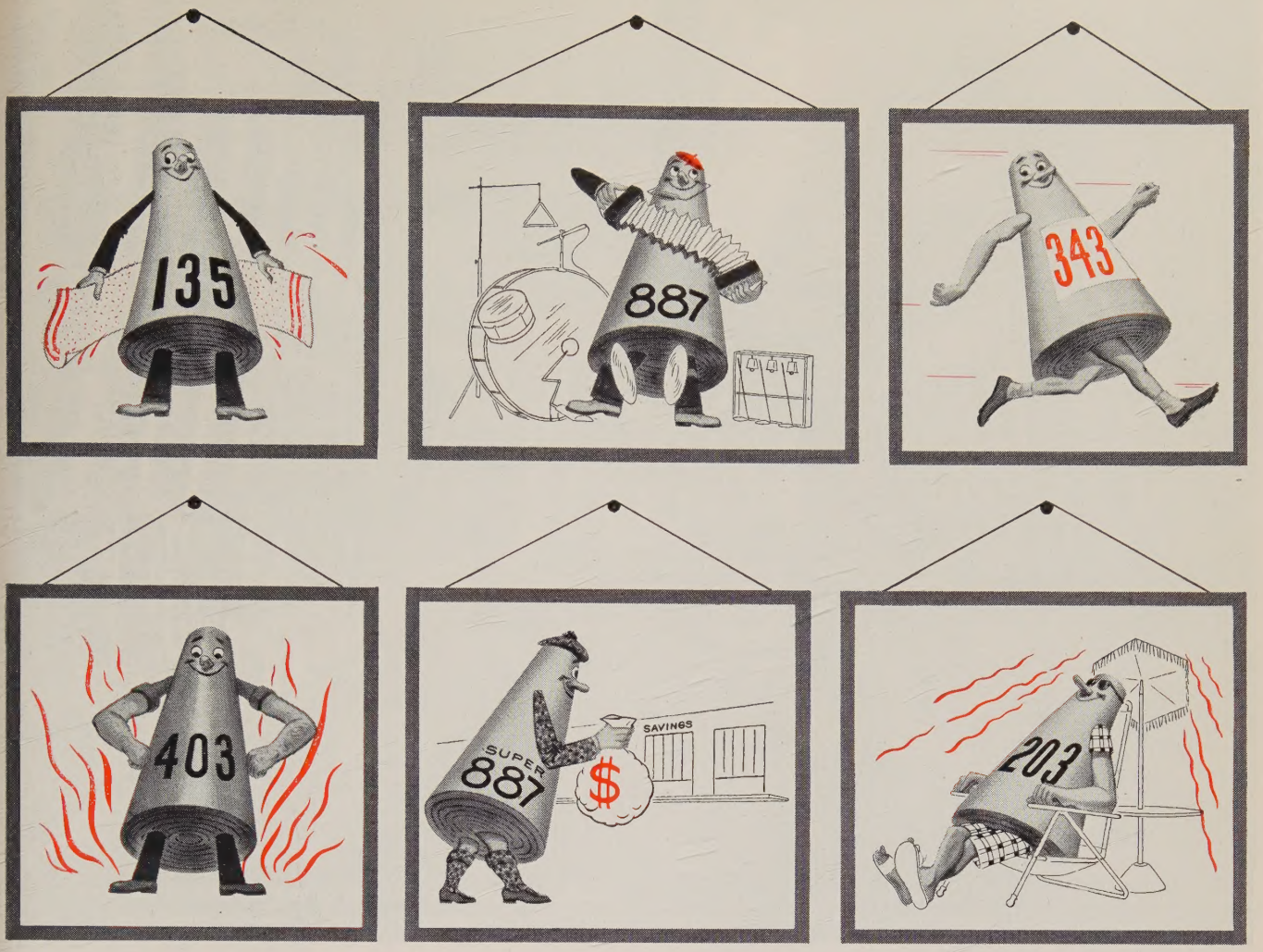

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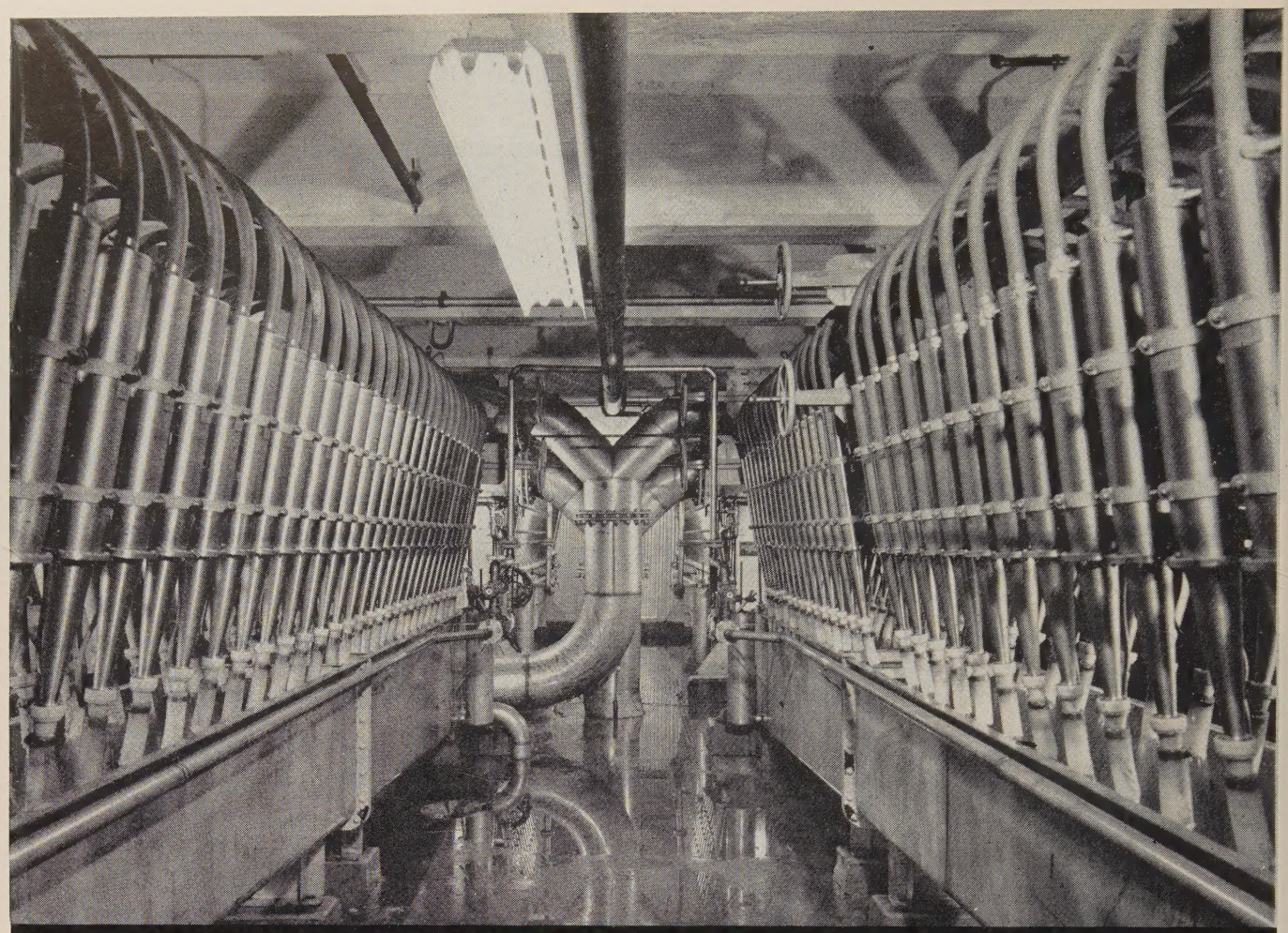

Showing some of the 280 Bird Cycleans on the job at Publishers Paper Co., Oregon City, on unbleached sulphite. These are 4" units (available with patented, non-plugging automatic purge tips); Cycleans also come in 7" and 12" sizes to meet a wide range of capacity requirements.

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46th Annual Meeting
Commodore Hotel, New York, N. Y.
Feb. 19–23, 1961

Twelfth Coating Conference
Statler-Hilton Hotel, Buffalo, N. Y.
May 22–24, 1961

Twelfth Testing Conference
Queen Elizabeth Hotel, Montreal, Que.
Aug. 15–18, 1961

Eleventh Corrugated Containers Conference
St. Francis Hotel, San Francisco, Calif.
Sept. 11–13, 1961

Please refer to Local Section Activities for the locations and dates of Section meetings

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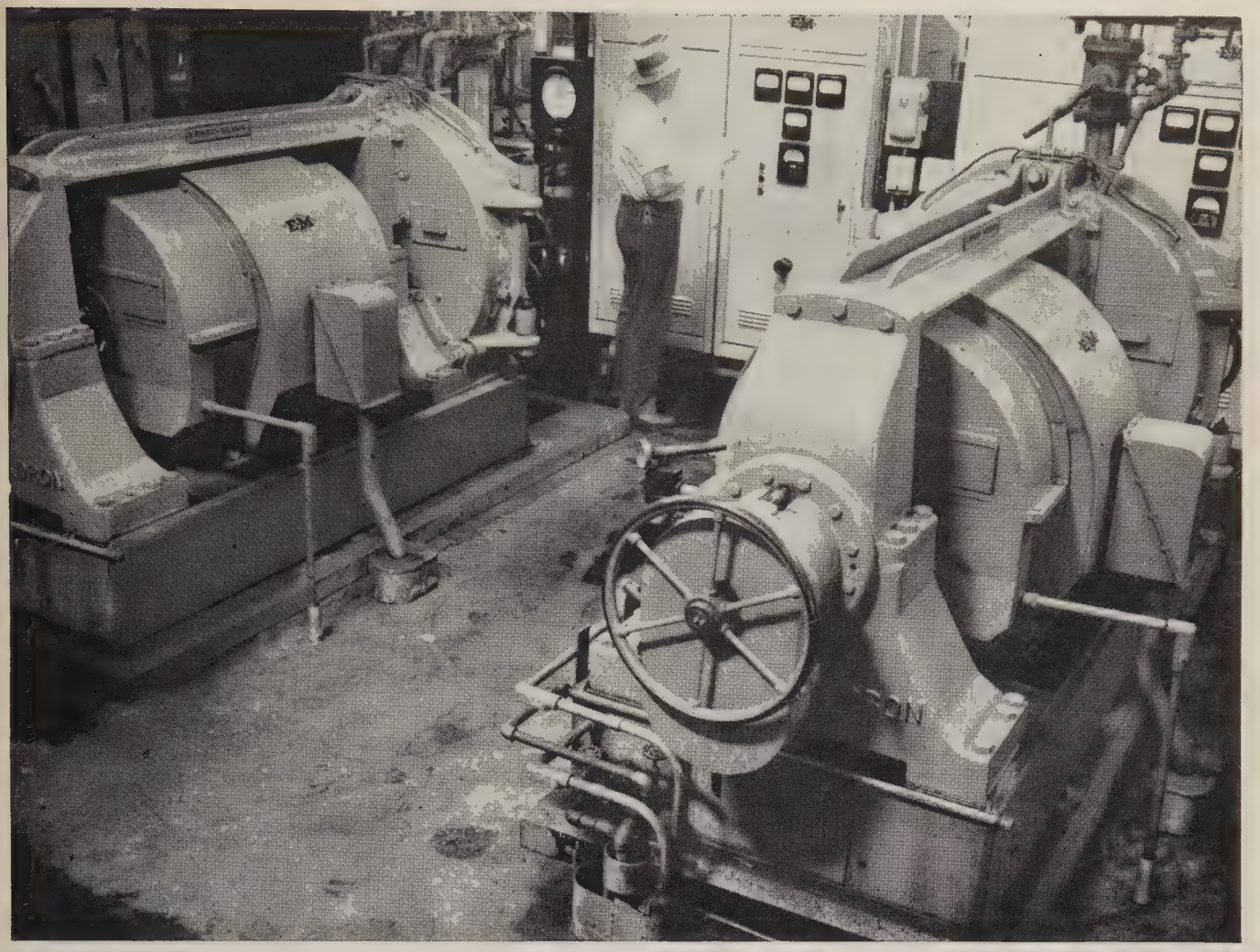

Two of the 33 E-M Synchronous Motors driving refiners at Masonite. The motors are rated 450 hp, 900 rpm, unity or 0.8 leading power factor. The motor controls shown are high interrupting capacity, current-limiting SA-FUSE type — also manufactured by E-M.

EIGHT YEARS AGO MASONITE SELECTED A 450 HP E-M SYNCHRONOUS MOTOR— *TODAY THEY HAVE 33 ON REFINER DRIVE!*

Masonite Corporation of Laurel, Mississippi now uses a total of 14,850 E-M horsepower!

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So, when you need paper mill motors with proven dependability, call your nearby E-M Sales Engineer. Also, write the factory today for your free copy of illustrated Booklet No. 49 which features Protective Motors.

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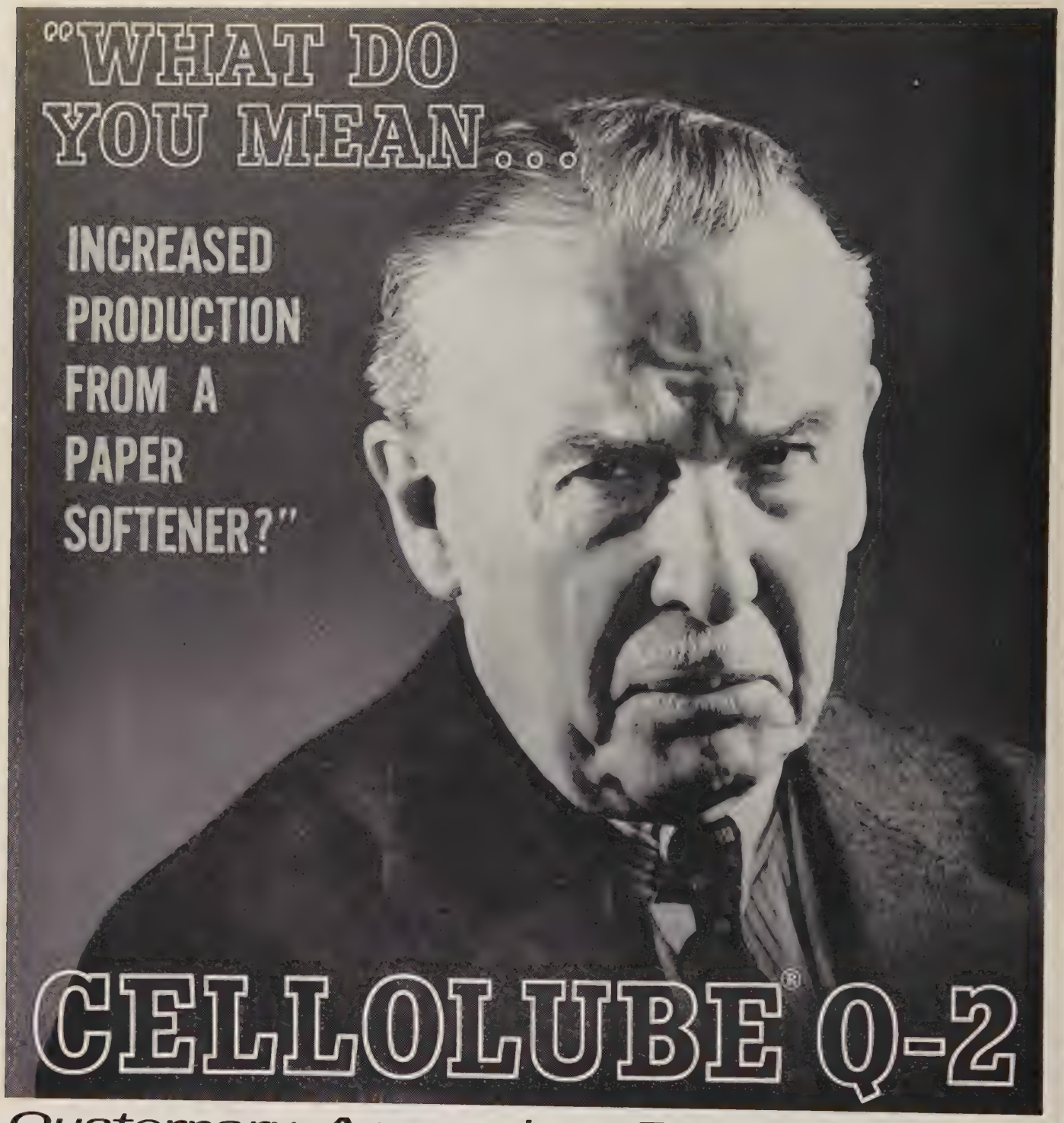
Specialists ***in making motors do*** **EXACTLY WHAT YOU WANT THEM TO**



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For Cellolube Q-2 not only gives a softer, more "sellable" sheet, but it boosts production and cuts production costs as well!

A few seconds after Cellolube Q-2 is added, its unique lubricating action goes to work . . . and *paper output increases from 10 to 20%*, due to stepped-up machine speed. And when speed is electronically controlled, production stays constant but *power demand drops.*

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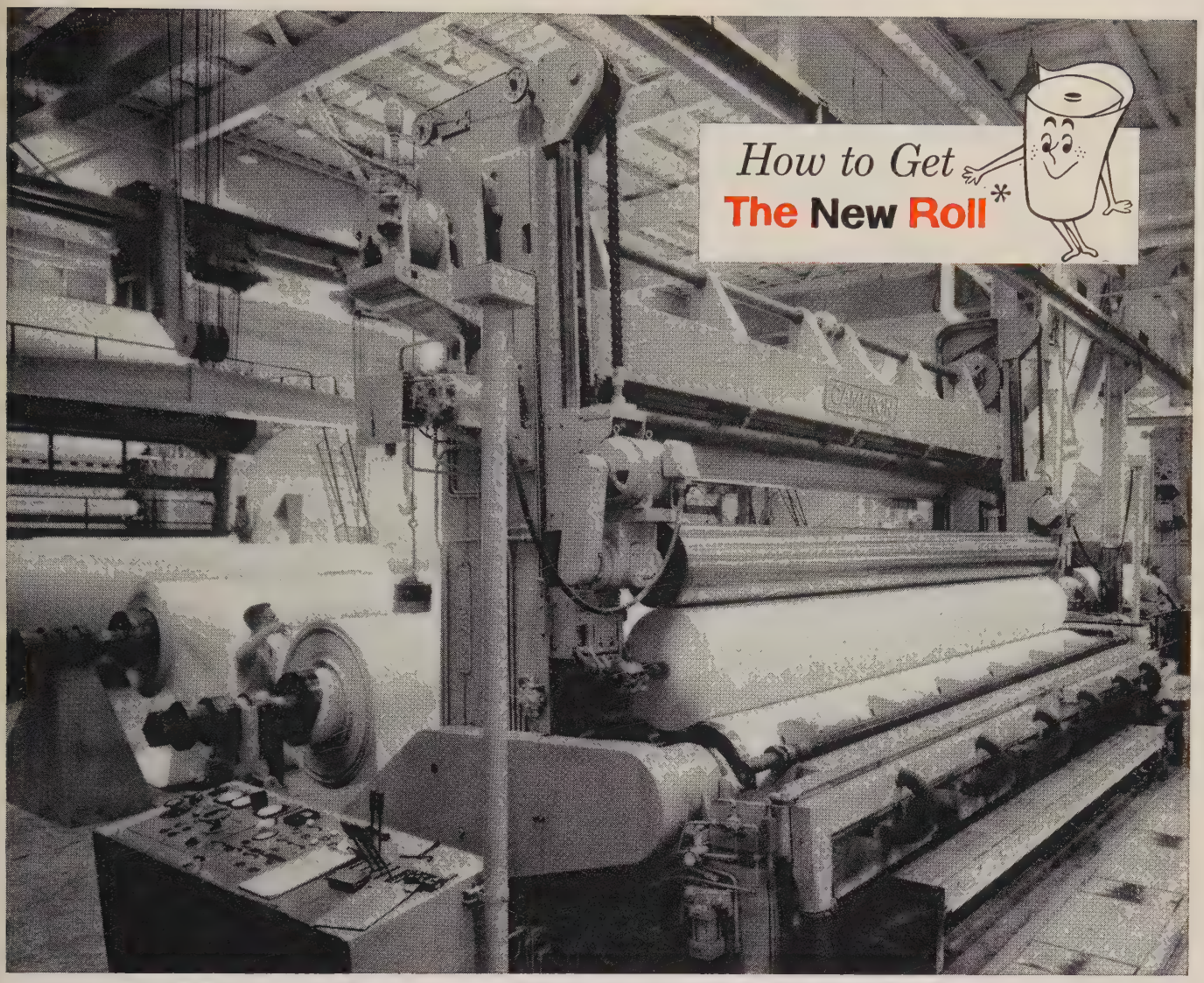

CAMERON IMPERIAL WINDER serving with a high speed supercalender at the St. Francisville (La.) mill owned jointly by Crown Zellerbach and Time Inc.

*the finished roll of superb new quality!

It is sometimes expedient to purchase a winder as part of a mill or finishing room "package" installation. Even so, there is no reason to wind up with less than the superb quality of *The New Roll!* A Cameron integrated winding system, job-fitted by Cameron specialists, may be purchased for use with any paper machine of any make, or with any coating or calendering machine. *And that's the only way to get The New Roll!*

In the action photograph above a new Cameron Imperial winding system, integrated from unwind to rewind, (246″ trim width, 72″ rewind capacity) is running at speeds up to 5000 fpm* on 28 to 85 lb. coated book papers. Here are some of the features of this job-fitted Cameron system:

Roll control starts with a Cameron H3PMR continuous duty unwind brake responding to signals from a Cameron cam controlled adjustable automatic tension sensing system. Easy setups with tight starts and firmly set cores are assured by such features as the Cameron hydraulic riding roll lift, and hydraulic down-pressure control. Other features which contribute to superb roll quality are the riding roll driven at both ends for even torque distribution, differential speed rewind drums which play a star role in Cameron automatic roll density control, and the Cameron isolated gear box which drowns main drive vibration. Minimizing downtime and contributing to high productivity are such features as the Cameron automatic shaft injector, the Cameron hydraulic roll lowering table with Cameron automatic shaft puller and core loader, the air-operated Cameron Quick-set shear cut slitters, and the centralized control panel.

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*Speed of Cameron Imperial is rated in excess of 8000 fpm depending upon machine width, number of cuts, tension, and characteristics of material.

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famous TIDLAND pneumatic shafts are sold exclusively through Cameron

The Market for Paper, Paperboard, Flexible Film, and Organic Papermaking Chemicals

GEORGE H. GOLDSBOROUGH

SUMMARY

During 1959 production of paper and paperboard totaled slightly more than 34 million tons. U. S. Department of Commerce projections made in 1957 indicate that this total will reach 43,800,000 tons by 1965—an increase of almost 5% per year. The production of special food board is expected to increase about 18% per year; building paper 9%; newsprint 7%; nonbending paperboard 6%; coarse, special industrial, sanitary, and tissue paper 4%; and printing and fine papers and other containerboard 2 to 3%.

Projections of paper and board production for the year 2000 range from that made in 1958 by the Forest Service, U. S. Department of Agriculture, of 105 to 135 million tons, to 155 million tons made in June 1960 by the U. S. Department of Commerce and 240 million tons made in April 1960 by Resources for the Future, Inc.

Production of flexible film in 1959 was approximately 462,000 tons.* About 72% was used for pack-

THIS report is designed to present a general picture of the current and prospective size of the market for paper, paperboard, flexible film, and the organic chemicals used in paper manufacture, and an indication of the competitive position of these materials relative to properties and costs. Detailed discussion of the market for aluminum foil and heavy gage-transparent sheeting was excluded from this paper.

Secondary data provided the basis for much of this report. However, economists and statisticians in Federal agencies and trade associations responsible for reporting statistical data on the products involved were interviewed to obtain additional data and interpretations of some of the more fragmentary information. In addition, a few key paper research development and sales personnel associated with research institutions, paper chemical suppliers, and film manufacturers were interviewed relative to the properties and market potential of these products.

GEORGE H. GOLDSBOROUGH, Staff Specialist (Paper), United States Department of Agriculture, Agricultural Research Service, Office of Administrator, Product and Process Evaluation Staff, Washington 25, D. C.

* Production of heavy gage transparent sheeting and aluminum foil in 1959 totaled about 74,000 and 108,000 tons, respectively.

Summary Table. Production of Paper, Paperboard, and Flexible Film and Consumption of Organic Chemicals in Paper Manufacture, Specified Years, United States[a]

Item	Year, 1000 Tons								1959 over 1954, per cent Increase	1965 over 1959, per cent Increase	2000 over 1959, per cent Increase
	1954	1955	1956	1957	1958	1959	1965	2000			
Paper and Board											
Paper	11,649	12,897	13,990	13,593	13,525	14,923	18,300	...	28.1	22.6	...
Paperboard	12,326	14,048	14,381	14,194	14,293	15,847	21,000	...	28.6	32.5	...
Bldg. paper & board	2,901	3,209	3,070	2,891	2,979	3,281	4,500	...	13.1	37.2	...
Total	26,876	30,154	31,441	30,678	30,797	34,051	43,800	105,000 to 240,000	26.7	28.6	308 to 705
Flexible Films											
Cellophane (pkg.)	175	183	200	194	202	218	...	...	24.6	...	...
Cellophane (nonpkg.)	[c]	[c]	[c]	[c]	[c]	[c]	...	...	...	...	...
Polyethylene (pkg.)	33	n.a.	58	75	85	100	...	...	212.5	...	...
Polyethylene (nonpkg.)	n.a.	n.a.	n.a.	n.a.	72	73	...	...	...	...	...
Other films (pkg.)	18	n.a.	20	22	22	25	...	...	33.3	...	...
Other films (nonpkg.)[b]	40	n.a.	44	42	40	48	...	...	12.0	...	...
Subtotal (pkg.)	226	n.a.	278	291	309	343	...	...	51.8	...	...
Subtotal (nonpkg.)	...	...	...	...	111	119	...	...	...	...	...
Total	...	...	...	...	420	462	...	...	...	...	...
Papermaking Organic Chemicals											
Corn starch	347	393	406	403	418	445	...	...	28.2	...	...
Tapioca, potato, and wheat starch	n.a.	n.a.	n.a.	n.a.	n.a.	139	...	...	...	...	...
Rosin	114	125	109	132	141	148	...	...	29.8	...	...
Wax	n.a.	n.a.	n.a.	n.a.	n.a.	95	...	...	...	...	...
All other	...	...	...	...	...	194	...	...	...	...	...
Total	...	...	...	...	...	1021	...	...	...	...	...

[a] Details of and footnotes to data shown here and in summary text included on Tables I, III, IV, and IX following.
[b] Cellulose acetate and polyvinyl chloride. Does not include the volume of "pliofilm," "vitafilm," "videne," "mylar," "saran," polyvinyl alcohol and "cryovac" used for nonpackaging.
[c] Reliable data not available. Informed sources indicate very little used for nonpackaging.

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aging and 28% for nonpackaging uses, such as shower curtains, tablecloths, plastic drapes, and protective covering for dry-cleaned clothing. In the past 10 years the dollar sales of film for packaging increased at a rate of about 13% per year compared to 4.1% for paper containers and 4.3% for all consumer containers. A large proportion of this increase was contributed by cellophane and polyethylene. Since 1954, the rate of growth of polyethylene production has exceeded that of competing films. In the opinion of film makers and researchers interviewed, polyethylene and polypropylene, a new film, are expected to lead the way in the future growth of the film market primarily because they have good properties and are less costly than cellophane and other competing films.

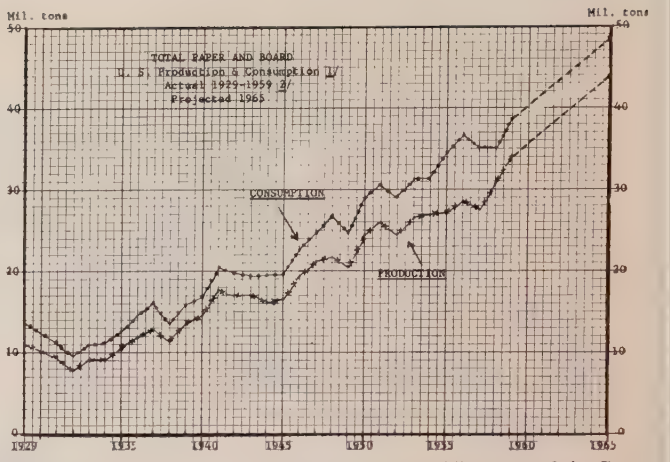
In 1959 the quantity of organic chemicals used by the paper industry totaled about 1 million tons. Starch, rosin, and wax were the most important of these materials in terms of volume consumed, comprising about 57, 14, and 9% of the total, respectively. In the past 6 years the rate of increase of corn starch and rosin consumption in the paper industry has about equalled the rate of increase of paper and board production. Similar trend data are not available for the other organic papermaking chemicals.

The consensus of persons interviewed relative to the potential market for chemicals of farm origin in papermaking and their competitive situation for this use was as follows:

1. Guar, with about four to six times the adhesive properties of starch, may be substituted in substantial quantities for starch as a fiber bonding agent, should guar drop in price moderately.

Papermakers are on the lookout for a fiber bonding agent with sufficient adhesive properties to eliminate the need for fiber beating. Such beating impairs certain fiber characteristics and causes additional fiber losses, though necessary at present to obtain adequate fiber bonding.

2. Starch may face increased competition as a surface size from polyvinyl alcohol. Five pounds of polyvinyl alcohol have about the same surface sizing capabilities as 18 lb. of starch and paper chemical suppliers indicate that polyvinyl may become more competitive in price.



Source: "Pulp, Paper, and Board Supply-Demand," Report of the Committee on Interstate and Foreign Commerce, June, 1957, and "Second Supplemental Report," July, 1959, to "Pulp, Paper, and Board Supply-Demand Report."

[1] Production plus imports minus exports.
[2] 1959 preliminary.

Fig. 1

3. Rosin size, a beater additive, is vulnerable to partial replacement by synthetic size if the price of rosin continues its current upward spiral. Paper chemical suppliers claim that 1 lb. of synthetic size, mostly chemically modified fatty acids, will achieve the same sizing properties as 8 to 9 lb. of rosin size.

4. The production of wet-strength paper and board will increase 10% per year and this increase will come largely from the growth in food grades, especially fresh produce master shipping containers. Wet-strength paper and board presently constitute about 3% of the total, or about 1 million tons. Wet-strength resins comprise about 2% of the finished product. Dialdehyde starch, or other chemicals of farm origin, have not yet had sufficient pilot plant and commercial testing to indicate whether they have a chance of making a substantial invasion of the market for wet strength additives.

5. Natural fatty acids and fatty acid esters have a major advantage over the much cheaper petroleum products as defoamers because of Food and Drug Administration objections to the use of kerosene and fuel oil as defoamers for food paper and board.

Table I. Paper and Board—U. S. Production, Actual 1956–59 and Projected 1965
(Thousand Short Tons)

Grade	*Actual production*				*Net demand, required U. S. production*		
	1956[a]	*1957*[a]	*1958*[a]	*1959*[b]	*1965*[b]	*1965 over 1959* — *Per cent increase*	*1965 over 1959* — *Annual rate of growth, %*
Total paper and board	31,441	30,678	30,797	34,051	43,800	28.6	4.8
Total paper	13,990	13,593	13,525	14,923	18,300	22.6	3.8
Newsprint	1,620	1,797	1,723	1,920	2,700	40.6	6.8
Printing papers	4,304	4,051	4,031	4,525	5,100	12.7	2.1
Fine papers	1,575	1,511	1,568	1,706	2,000	17.2	2.9
Coarse and special industrial papers	4,631	4,322	4,242	4,689	5,900	25.8	4.3
Sanitary and tissue papers	1,860	1,912	1,961	2,083	2,600	24.8	4.1
Total paperboard	14,381	14,194	14,293	15,847	21,000	33.1	5.5
Containerboard	7,763	7,629	7,658	8,621	10,600	23.0	3.8
Bending board (except special food board)	2,822	2,868	2,912	3,174	3,800	19.7	3.3
Special food board	1,290	1,281	1,330	1,476	3,100	110.0	18.3
Nonbending and other paperboard	2,506	2,416	2,393	2,576	3,500	35.9	6.0
Total building paper and board	3,070	2,891	2,979	3,281	4,500	37.2	6.2
Building paper	1,428	1,328	1,349	1,382	2,200	59.1	9.9
Building board	1,642	1,563	1,630	1,899	2,300	21.1	3.5

[a] From "Second Supplemental Report"—July, 1959, to "Pulp, Paper and Board Supply-Demand Report" (submitted to the Subcommittee on Commerce and Finance of the House Interstate and Foreign Commerce Committee in June 1957), U. S. Department of Commerce, Business and Defense Services Administration.
[b] Preliminary; From "Facts for Industry" Pulp, Paper and Board, Bureau of the Census.

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6. The use of soybean protein and casein in papermaking is likely to increase at a slightly faster rate than the production of paper and board because of the tendency to upgrade end products by manufacturers.

FINDINGS

A. Paper and Paperboard

During 1959 United States production of paper and paperboard reached a record high of slightly more than 34 million tons (Table I). Projections made by the Business and Defense Services Administration in a report entitled, "Pulp, Paper and Board Supply-Demand," made to the House Committee on Interstate and Foreign Commerce, July, 1959, indicate that production will approximate 43,800,000 tons per year by 1965. This increase of about 28.6%, or 4.8% per year, is based on an analysis of long time trends in growth plus assumed levels of national economic activity. Figure 1 shows total paper and board production and consumption (production plus imports minus exports) from 1929 to 1959, with projections to 1965.

Percentagewise, the growth rate for special food board is expected to substantially exceed the industry average (Table I). Above average demand is also expected for newsprint, building paper, and nonbending and other paper board. On the other hand, printing and fine paper production and output of bending and containerboard and building board are expected to lag behind the industry average.

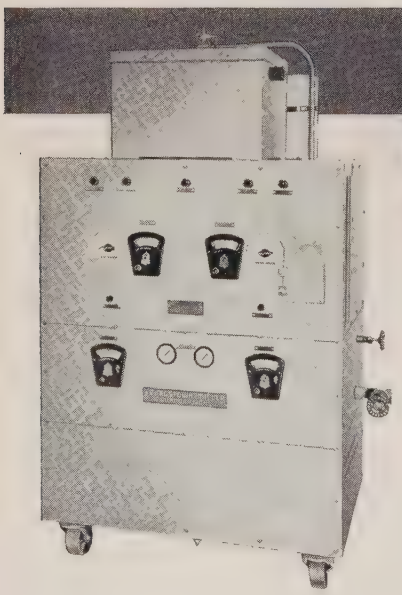
Projections of paper and board production for the year 2000 range from that made in 1958 by the Forest Service, U. S. Department of Agriculture, of 105 to 135 million tons, to 155 million tons made in June, 1960, by the U. S. Department of Commerce and 240 million tons by Resources for the Future, Inc.* The differences in the projections may be ascribed primarily to differences in basic assumptions, such as rate of population growth, rather than to differences in mathematical techniques. Pulpwood requirements in line with the projections would range from 116 million cords for the median Forest Service projection to 264 million cords for the R.F.F. projection.

Except for newsprint, virtually all this country's supply of paper and paper board is produced domestically (Table II). Seventy-five to eighty per cent of our newsprint is imported, mostly from Canada.

B. Flexible Films

1. Production. In 1959 the production of flexible films for all purposes equalled 462,000 tons, up about 11% from a year earlier (Table III). About 72% of this total was used for packaging and 28% for nonpackaging purposes. Cellophane was used primarily for packaging; cellulose acetate and polyvinyl chloride for nonpackaging purposes; and polyethylene about 60% for packaging and 40% for nonpackaging. There are no data on the volume of "other films" used for nonpackaging. Materials classified as "other films" include "pliofilm," "vitafilm," polyvinyl alcohol, "videne," "mylar," "saran," and "cryovac." Some of the

* Estimates set forth in "Pulp, Paper and Board" Industry Report, Vol. XVI, No. 2, June, 1960, Business and Defense Services Administration, U. S. Department of Commerce, Washington, D. C.



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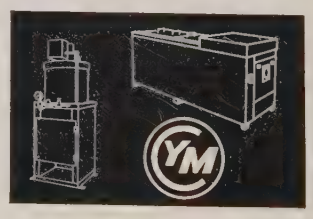

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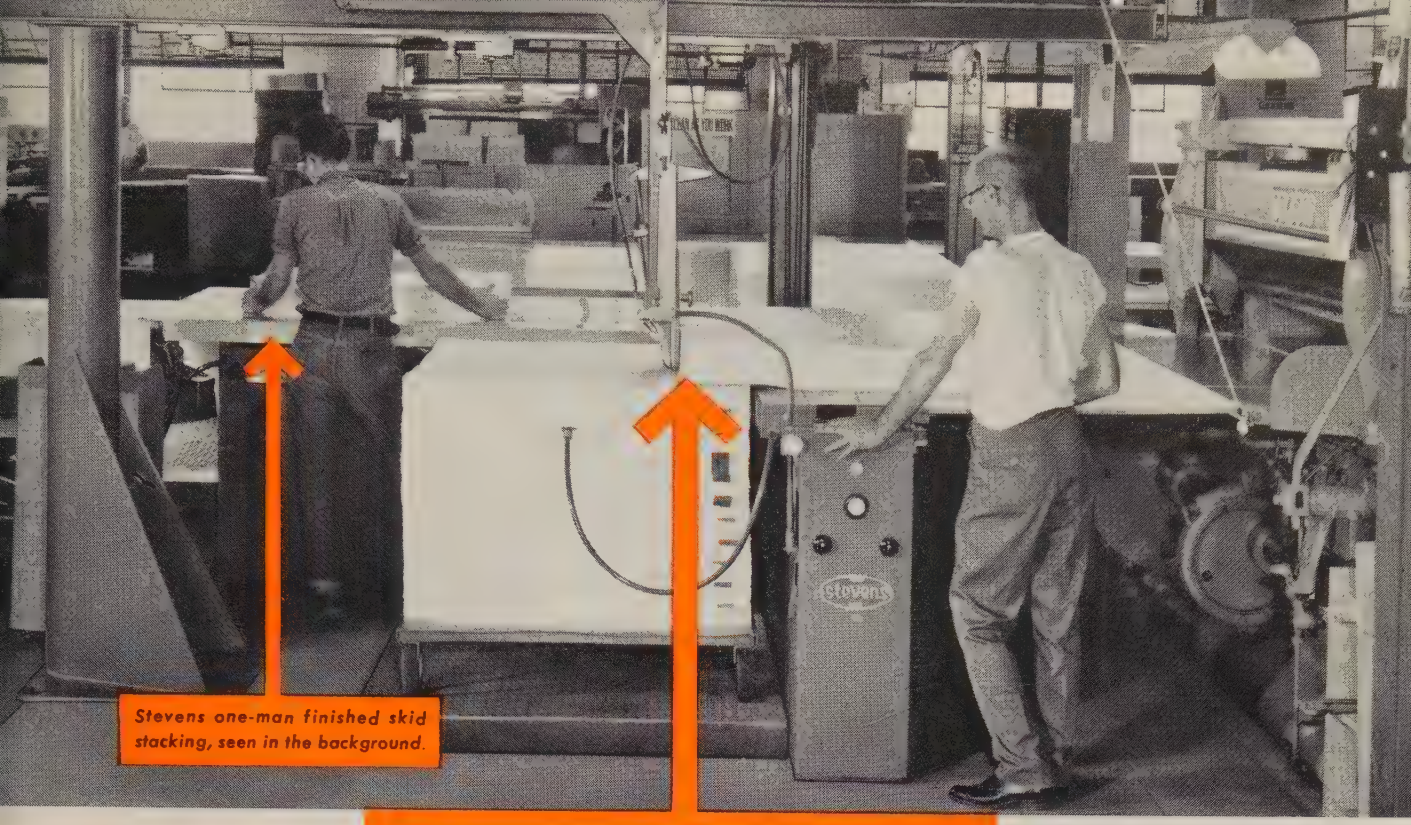

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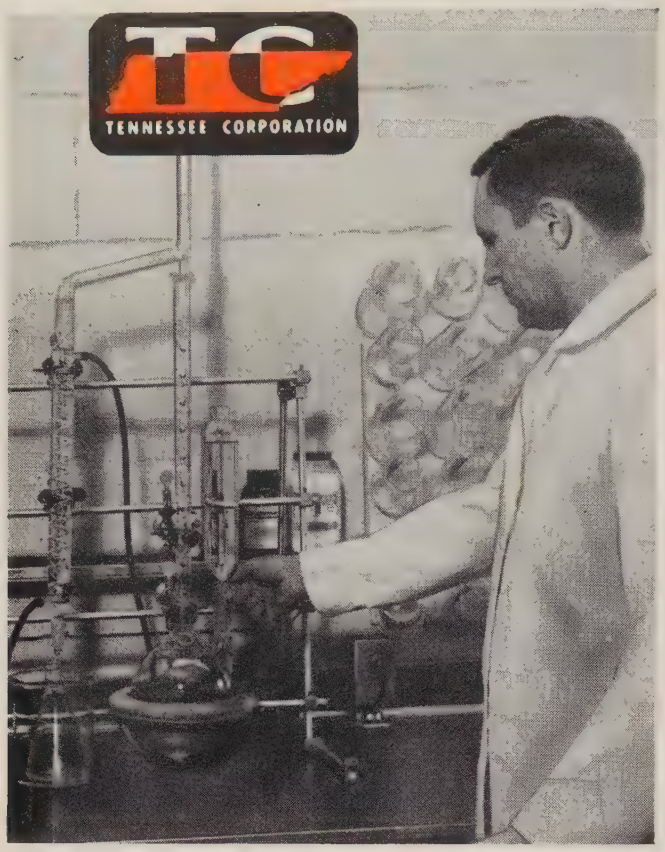

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Table II. Paper and Board—U. S. Production, Imports, Exports, and Apparent Consumption, 1956–58

(Thousand short tons)

Item and year	Production	Imports	New supply	Markets: Exports	Markets: Apparent consumption
Total paper and board					
1956	31,441	5,800	37,241	669	36,342
1957	30,678	5,422	36,100	751	35,276
1958	30,797	5,100	35,897	729	35,190
Total paper					
1956	13,990	5,679	19,669	330	19,109
1957	13,593	5,306	18,899	375	18,451
1958	13,525	4,980	18,505	335	18,192
Newsprint					
1956	1,620	5,569	7,189	152	6,807
1957	1,797	5,221	7,018	174	6,771
1958	1,723	4,883	6,606	127	6,501
Printing papers					
1956	4,304	55	4,359	45	4,314
1957	4,051	38	4,089	46	4,043
1958	4,031	37	4,068	52	4,016
Fine papers					
1956	1,575	3	1,578	34	1,544
1957	1,511	4	1,515	39	1,476
1958	1,568	4	1,572	33	1,539
Coarse and special industrial papers					
1956	4,631	49	4,680	89	4,591
1957	4,322	41	4,363	104	4,259
1958	4,242	54	4,296	109	4,187
Sanitary and tissue papers					
1956	1,860	3	1,863	10	1,853
1957	1,912	2	1,914	12	1,902
1958	1,961	2	1,963	14	1,949
Total paperboard					
1956	14,381	33	14,414	300	14,114
1957	14,194	37	14,231	338	13,893
1958	14,293	39	14,332	362	13,970
Container board					
1956	7,763	12	7,775	213	7,562
1957	7,629	18	7,647	255	7,393
1958	7,658	19	7,677	267	7,410
Bending board (except special food board)					
1956	2,822	[a]	2,822	46	2,776
1957	2,868	[a]	2,868	38	2,830
1958	2,912	[a]	2,912	44	2,868
Special food board					
1956	1,290	[b]	1,290	[c]	1,290
1957	1,281	[b]	1,281	[c]	1,281
1958	1,330	[b]	1,330	[c]	1,330
Nonbending and other paperboards					
1956	2,506	21	2,527	41	2,486
1957	2,416	19	2,435	45	2,390
1958	2,393	20	2,413	51	2,362
Total building paper and board					
1956	3,070	88	3,158	39	3,119
1957	2,891	79	2,970	38	2,932
1958	2,979	81	3,060	32	3,028
Building paper					
1956	1,428	2	1,430	10	1,420
1957	1,328	1	1,329	12	1,317
1958	1,349	1	1,350	11	1,339
Building board					
1956	1,642	86	1,728	29	1,699
1957	1,563	78	1,641	26	1,615
1958	1,630	80	1,710	21	1,689

[a] Included in container board.
[b] Not reported separately.
[c] Included in bending board.

Note: New supply equals production plus imports. Apparent U. S. consumption equals new supply minus exports, adjusted for newsprint inventories, 1956 and 1957 revised; 1958 preliminary.

Source. "Second Supplemental Report" July, 1959, to "Pulp, Paper and Board Supply-Demand Report" (submitted to Subcommittee on Commerce and Finance of House Interstate and Foreign Commerce Committee in June, 1957).

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Table III. Production of Flexible Films, United States, 1954 and 1956–59

(1000 Tons)

Item	1954	1955	1956	1957	1958	1959
Cellophane						
Packaging	175	183	200	194	202	218
Nonpackaging	[d]	[d]	[d]	[d]	[d]	[d]
Polyethylene[a]						
Packaging	33	n.a.	58	75	85	100
Nonpackaging	n.a.	n.a.	n.a.	n.a.	72	73
Cellulose Acetate (under 0.003 gage)						
Packaging	4	4	4	4	3	4
Nonpackaging	5	5	6	5	5	5
Polyvinyl Chloride[b]						
Packaging	2	n.a.	2	2	2	3
Nonpackaging	33	n.a.	37	35	34	41
Other Films[c]						
Packaging	12	n.a.	14	16	17	18
Nonpackaging	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Subtotals						
Packaging	226	..	278	291	309	343
Nonpackaging	..	..	..	..	111[e]	119[e]
Grand total	..	..	..	..	420	462

[a] Includes sheeting as well as film.
[b] Includes only the resin content of the finished film.
[c] Includes "pliofilm," "vitafilm," "videne," "mylar," "saran," and "cryovac." 1959 data also include polyvinyl alcohol.
[d] Reliable data not available. Informed sources indicate very small volume of cellophane used for non-packaging.
[e] Exclusive of "other films." Data on volume of other films used for non-packaging not available.
Source. Estimated from data in files and published reports of U. S. Dept. of Commerce and U. S. Tariff Commission. In some cases data represent sales.

nonpackaging uses for flexible films are in the manufacture of tablecloths, shower curtains, plastic drapes, and protective coverings for dry-cleaned garments. Flexible films are also used in construction and in agriculture for trench silos and mulching.

Polypropylene is a new product with many of the characteristics of polyethylene. Industry apparently expects great things of this resin in view of the fact that a number of plants with large capacities are now coming into production and total output is expected to be substantial in 1960.

The rate of growth in the market for packaging films in the past 10 years has far exceeded that for other types of containers and packaging materials (Table IV). The major part of this increase has been contributed by cellophane and polyethylene (Table III). The production of cellulose acetate, polyvinyl chloride, and other films has remained comparatively stable. Future growth is expected to come primarily from increases in polyethylene and polypropylene production.

Information for 1958 indicates that the products which were packaged in important quantities with cellophane were baked goods, meat and poultry, tobacco, and candy (Table V). Polyethylene, on the other hand, was the principal film for wrapping fresh produce. Other films were used primarily to package meat and poultry. It is estimated that by 1963 polyethylene will also become important in the packaging of baked goods, frozen foods, and textiles, but that there will be little change in the end use pattern of cellophane.

Table V. Estimated Sales Distribution of Packaging Films[a]

(1000 Tons)

End use	Cellophane 1958	Cellophane 1963*	Polyethylene 1958	Polyethylene 1963*	All others 1958	All others 1963*
Candy	17.5	24.0	2.3	3.5	3.0	5.0
Tobacco	20.0	35.0	0.5	1.5	0.0	1.5
Meat and poultry	23.0	27.5	2.5	6.0	12.5	25.0
Frozen foods	13.0	17.5	3.2	12.5	0.1	1.5
Baked goods	67.5	50.0	1.5	30.0	0.5	15.0
Textiles	2.0	0.5	6.0	10.0	0.2	4.0
Dairy products	6.5	7.5	3.0	4.0	2.5	3.5
Fresh produce	5.0	6.0	34.0	57.5	2.0	3.0
All others	47.0	72.0	34.5	50.0	11.7	15.0
Totals	201.5	240.0	87.5	175.0	32.5	73.5

[a] Data from "Modern Packaging Encyclopedia," 1960 issue. 1958 aggregate sales estimates for polyethylene and "all others" slightly higher than 1958 production estimates (see Table III).
* Based on projection of current statistics.

2. Prices. Table VI presents 1959 price comparisons for the principal films and glassine and waxed papers. The prices shown are approximately the same as those existing in 1954 and there have been no important fluctuations since that time. On the basis of price per 1000 sq. in., polyethylene is less costly than most competing films and is competitive with glassine and waxed papers, accounting in part for its marked growth pattern. It is understood that polypropylene priced at $0.030 per 1000 sq. in. in 1959, can now be priced at about $0.026 per 1000 sq. in. due to increased yields. The orienting of polypropylene, a comparatively new development for this film, reduces the thickness required and actually improves certain properties.

3. Properties. Film producers indicate that packaging films must have five basic properties to successfully compete in today's market. These are: (1) merchandisability (clarity, good appearance, and cleanness), (2) machine runability; i.e., capable of being used on very high-speed machines, heat seal neatly, and operable on both push and pull type machines (cellophane has superior runability characteristics and this property is largely responsible for its success in maintaining its outlets in competition with lower priced polyethylene), (3) must lend itself to

Table IV. Ten-year Growth Index of Containers and Packaging Industries, United States

Year	Gross national product, based on 1957 constant dollars	Total all containers and packaging materials[a]	Containers[a] Metal	Paper	Wood	Glass	Textile	Components[a] Closures	Films for packaging	Shipping versus consumer-type containers[a] Shipping	Consumer
1959*	135	133	123	141	83	140	83	95	230	117	143
1958	124	126	116	134	78	132	79	95	209	110	136
1957	128	125	115	134	82	133	78	96	197	113	133
1956	126	128	121	135	88	130	86	102	194	116	135
1955	123	122	114	129	90	127	87	102	175	114	127
1954	114	111	104	115	87	116	107	95	155	104	116
1953	116	111	103	115	97	118	105	95	129	107	110
1952	111	101	97	102	96	106	98	93	114	98	103
1951	108	105	100	109	100	106	93	99	116	107	104
1950	100	100	100	100	100	100	100	100	100	100	100

[a] Indexes based on dollar volume.
* Estimated.
Source: "Modern Packaging Encyclopedia," 1960 issue.

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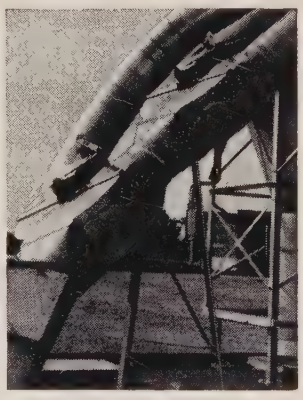

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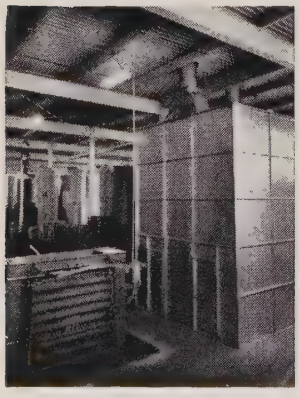

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Table VI. Prices of Specific Packaging Papers and Films, 1959

Material[a]	*Price per lb.*$ [b]	*Yield sq. in. per lb.*	*Price per 1000 sq. in.,* $
Glassine			
Bleached, 25 lb.[c]	0.248	17,280	0.014
Lacquer, coated, moisture-proof heat-sealing, 28 lb.[c]	0.455	15,428	0.030
Laminated, amber, 47 lb.[c]	0.30	9,191	0.033
Laminated, bleached, 47 lb.[c]	0.31	9,191	0.033
Waxed paper			
Bread wrapper grade, 39 lb.	0.23	11,080	0.021
Liner grade, moisture-proof, amber, 29 lb.	0.283	14,897	0.019
Cellophane			
Moisture-proof, heat-sealing			
(300 gage MS) 1 mil thick	0.62	19,500	0.032
(300 MS 51 or MS-1 type)	0.62	21,000	0.030
Moisture-proof, water resistant			
(300 MSA or MSB)	0.69	19,500	0.035
Polymer-coated (300K, OX, or R)	0.79	19,500	0.041
Cellulose acetate			
Cast (1 mil)	0.93	22,000	0.042
Extruded (1 mil)	0.74	22,000	0.034
Cryovac (60 gage)	1.17	28,700	0.040
Pliofilm (SS-75)	1.10	33,000	0.033
Polypropylene (1 mil)	0.93	30,700	0.030
Polystyrene, oriented (1 mil)	0.60	25,400	0.024
Polyester film—"Mylar"			
(1 mil)	1.80	20,000	0.090
(1/2 mil)	2.50	40,000	0.063
Heat-sealing (2 mil)	2.60	13,400	0.194
Polymer-coated (1/2 mil base)	2.50	27,500	0.091
Polyethylene			
Low density (1 mil)	0.56	30,000	0.019
Low density (1.5 mil)	0.53	20,000	0.027
Medium density	0.68	30,000	0.023
High density (1 mil)	0.74	29,000	0.026
Polyethylene cellophane			
(1 mil poly-300 MS)	1.07	11,800	0.091
Saran (1 mil)	1.08	16,300	0.066
Vinyl			
Cast (1 mil)	0.87	21,600	0.040
Extruded (1 mil)	0.73	21,500	0.034

[a] Typical packaging gages, standard commercial grades, unprinted.
[b] Prices obtained from 1959 price lists and are based on volume orders.
[c] Based on a ream of 500 sheets, 24 by 36 in., or 3000 sq. ft.
Source. "Modern Packaging Encyclopedia," 1960 issue.

processing for wide ranges of water, vapor or grease permeability, (4) durability, and (5) low cost.

Industrial films (such as "mylar," polyethylene, and polypropylene) should have (1) high durability, tensile strength, and puncture resistance, (2) good electrical properties, (3) ability to retain properties at temperatures up to 500° F., (4) chemical, solvent, and weathering resistance, (5) fabricability, and (6) good release properties (will not adhere to wrapped material or to itself if wound on a reel).

Comparisons of the properties of the various packaging films are shown on Table VII. The properties of closely competing packaging papers are shown on Table VIII.

C. Organic Chemicals in Paper and Paperboard Production

The principal organic chemicals used in paper and paperboard making are corn, wheat, potato and tapioca starches, casein, soybean protein, animal glue, rosin, latices, acrylics, waxes, kerosene, fatty acids, fatty acid esters, glycerine, vegetable gums and oils, asphalt emulsion, alginates, carboxymethylcellulose, dextrin, synthetic size, urea-formaldehyde, and urea, melamine, polyamide, gum, phenolic, vinyl, and styrene resins. Table IX shows total consumption of these materials in 1959. Except for rosin and corn starch, the most important materials in terms of volume used,

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Table VII. Properties of Packaging Films

(Basic types and accepted commercial standards are given here, however, many special grades are available)

Properties	Lacquered	Cellophane Polymer-coated	Polyethylene-coated[e]	Cellophane[g]	Cryovac	Pliofilm	Polyester
			General				
1. Type of material	Lacquered regenerated cellulose (heat-sealable)	Polymer-coated regen. cellulose (heat sealable)	Extrusion coated	Cellulose acetate	Saran resin blend	Rubber hydrochloride	Polyester resin plain or coated
2. Forms available	Sheets, rolls	Sheets, rolls	Sheets, rolls	Sheets, rolls	Seamless tubes, bags, films[h]	Continuous rolls, sheets	Sheets, rolls
3. Clarity	Transparent or colored	Transparent	Transparent to translucent	Transparent or colored	Transparent to opaque or colored	Transparent to opaque	Transparent
4. Thickness, in.	0.0009–0.0017	0.001 to 0.0011	0.002 or more	0.0005–0.002	0.0008–0.003	0.0004–0.0025	0.00025 and thicker
5. Maximum width, in.	60	46	60	52	Variable	60	50–55
6. Yield[a]	19,500	19,500	11,800 (2-mil combination)	22,000	16,700	24,000	20,000 to 25,000
7. Approximate specific gravity	1.40–1.55	1.44	1.2	1.25–1.35	1.64	1.11	1.15–1.39
			Mechanical				
8. Tensile strength, lb./sq. in.	7,000–16,000	7,000–13,000	5,000 and over	7,000–12,000	6,000–12,000	5,500–7,500	17,000 and higher
9. Elongation, %	15–25	25–50	15–25	15–50	50–100	Yield 10–20, ultimate 350–500	70–130
10. Bursting strength (Mullen), lb./sq. in.	...	...	40–50	50–85	20–35	Stretches	30–45 (1 mil)
11. Tearing strength, (Elmendorf), gm./mil	2–10[c]	7–15	16–50	2–15	15–20	60–1,600	13 to 80
12. Folding endurance	...	Over 15,000 (M.I.T.)	Good	...	Excellent	10,100–1,000,000 (M.I.T.)	Excellent
13. Heat-sealing range, °F.	200–300	225–350	230–300[f]	350–450[f]	275–300[f]	250–350[f]	275–400
			Chemical				
14. Water absorption in 24-hr. immersion test, %	70–100	50	...	3–7	Nil	Nil	Nil
15. Water-vapor permeability,[b] gm./24 hr./100 sq. in. at 100° F., 90% R.H.	0.2–1.0	0.5–0.9	1.2	100	1.0–1.4	0.5–15.0	1.0
16. Permeability to gases (oxygen, carbon dioxide)	Dry: very low Moist: variable[d]	Very low	Like cellophane	Medium	Very low	Low to high	Very low
17. Resistance to acids	Poor to strong acids	Poor to strong acids	Excellent	Poor to strong acids	Excellent	Good	Excellent
18. Resistance to alkalies	Poor to strong alkalies	Poor to strong alkalies	Excellent	Poor to strong alkalies	Good, except ammonia	Good	Excellent
19. Resistance to greases and oils	Impermeable	Impermeable	Like polyethylene	Excellent	Excellent	Excellent	Excellent
20. Resistance to organic solvents	Insoluble	Insoluble	Like polyethylene	Soluble except in hydrocarbons	Good to excellent	Sol. cyclic hydrocarbons, chlorinated solvents	Excellent
			Permanence				
21. Maximum use temperature, °F.	Begins to char at 375	Begins to char at 375	180	Approx. 300	Softens at 270, melts at 290	Softens at 200	230
22. Minimum use temperature, °F.	Depends on type and R.H.	About 0	Depends on cellophane	Brittle at subzero	Depends on plasticizer	Depends on plasticizer	−80
23. Resistance to sunlight	No effect	No effect	Excellent	Excellent	Good	Fair	Fair
24. Dimensional change at high R.H., %	3–5	2–3	3–5	0.6% at 80% R.H.	None	None	None
25. Resistance to storage	Deter. due to age negligible if proper storage conditions kept	Deter. due to age negligible if proper storage conditions kept	Good	Excellent	Good	Good if kept in dark	Excellent
26. Flammability	Same as newsprint	Same as newsprint	Slow burning	Slow burning	Self-extinguishing	Self-extinguishing	Slow burning

[a] Value in sq. in. per lb. per mil (0.001 in.) of thickness, where not otherwise indicated.
[b] Using $CaCl_2$ in test dish. Values reported are based on 1 mil (0.001 in.) of film. Value for some films depends on type and amount of plasticizer.
[c] Figures represent pull to tear after starting. Force to start tear is too high to measure on some equipment and normally is not determined.
[d] Depends on moisture content of film and type and amount of plasticizer.
[e] Cellophane-coated or laminated with 1-mil polyethylene. Test data assume polyethylene side toward product.
Source: "Modern Packaging Encyclopedia," 1960 issue.
[f] Unsupported film cannot be sealed on all types of heat sealers. Special sealing may be necessary.
[g] Modified acetates—cellulose acetate butyrate (Kodapak II) and cellulose triacetate (Kodapak IV)—offer an additional range of properties.
[h] Properties here are for bag material. Film type varies in certain properties: elongation 50–110; WVTR, 0.29–0.80; permeability to O_2, 75–250; permeability to CO_2, 400–1100—cc./24 hr./sq. meter/atm./mil. @ 72°F.
[i] Applies to coated grades only.
[j] Tests are performed in both cross and machine directions which accounts for range in values.

the consumption data represent only rough estimates. Trade sources believe these estimates to be rather conservative and the list of materials, especially for coatings, incomplete.

Statistical data on trends in use are nonexistent, except for corn starch and rosin. Consumption of these products has been increasing at about the same rate as total paper and board production since 1954.

A number of the enumerated chemicals are used as beater additives for fiber bonding and internal sizing; others for wet strength, defoaming, surface sizing, coating, corrugating and laminating. Most have a use in only one of these functions, a few in several.

1. Beater Additives. (*a*) Fiber Bonding Agents. The principal function of fiber bonding adhesives is to increase the strength of the paper. Other important functions are to increase retention of fillers, lay surface fuzz, increase the hardness and durability, increase the stiffness and rattle and to improve sizing.

Starch is the chief fiber bonding agent presently in

Table VII. Properties of Packaging Films

	Polyethylene						
	Low density, 0.910–0.925	*Medium density, 0.926–0.940*	*High density, 0.941–0.965*	*Polypropylene*	*Polystyrene, oriented*	*Saran*	*Vinyl*
	Polyethylene resin	Polyethylene resin	Polyethylene resin	Polypropylene resin	Polystyrene resin	Polyvinylidene chloride	Vinyl chloride, copolymers and plasticized combinations
	Rolls, sheets, tubing	Rolls, sheets, tubing	Rolls, sheets, tubing	Rolls, sheets	Rolls, sheets	Seamless tubes, rolls	Rolls
	Transparent to translucent or colored	Transparent to translucent	Transparent to translucent	Transparent to translucent	Transparent	Transparent, translucent, opaque	Transparent
	0.0005 or more	0.00035 or more	0.0005 or more	0.00075 or more	0.001 or more	0.0005–0.002	0.001 or more
	240	240	60	60	72	40	72
	30,000	29,500	29,000	30,677	26,100	16,300	21,600
	0.92	0.93	0.94 and up	0.90	1.05	1.68	1.23–1.29
				Mechanical			
	1,350–2,500	2,000–3,500	3,000–10,000	6,600–7,800	9,000–12,000	8,000–20,000	3,000–11,100
	50–600	50–500	50–400	200–600	10–20	40–80	5,250
	48	...	...	...	35–45	35	25–40
	150–350	50–300	15–300	40–330	20–30	10–20	Varies widely
	Very high	Very high	Very high	Very high	Good	Over 500,000 (M.I.T.)	Good
	250–350[f]	250–350[f]	275–350[f]	325–400[f]	250–325[f]	280–300[f]	200–350[f]
				Chemical			
	Nil	Nil	Nil	Nil	Nil	Nil	None to 5.5
	1.2	0.5–1.0	0.3–0.6	0.5–0.7	4.1	0.10–0.30	4–13
	High	Medium to high	Medium to high	Medium to high	Medium to high	Very low	Medium
	Excellent	Excellent	Excellent	Excellent	Good	Excellent except H_2SO_4 and HNO_3	Good
	Excellent	Excellent	Excellent	Excellent	Good to Excellent	Good except NH_4OH	Good
	May swell slightly on long immersion	Good	Excellent	Excellent	Good	Excellent	Good
	Excellent, but may swell slightly on long immersion	Excellent, but may swell slightly on long immersion	Excellent, but may swell slightly on long immersion	Eccellent	Poor to Good	Excellent	Soluble in some
				Permanence			
	180 (softens at 230)	180–220	230	250	Shrinks at 185	Softens at 290, melts at 310	Approx. 200 depend on plasticizer
	−60	−60	−60	−60	Subzero	Good flexibility at 0	Depends on plasticizer
	Fair	Fair	Fair	Fair to excellent	Limited	Excellent	Fair
	None	None	None	None	Little or None	None	None
	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
	Slow burning	Slow burning	Slow burning	Slow burning	Slow burning	Self-extinguishing	Self-extinguishing

use. Vegetable gums, such as guar and locust bean gum, are also used by many papermakers. Animal glue, soybean protein, and casein are not so widely used, but may be added to the beater to increase fiber retention, improve sizing or lay surface fibers. These proteins are $0.20 to $0.23 per lb., about three times as expensive as starch, with no material superiority in properties.

Guar, a comparatively new product, offers considerable promise as a bonding agent having four to six times the adhesive properties of starch. At present, guar ranges in price from $0.28 to $0.33 per lb., compared to $0.05 to $0.07 for starch. In some quarters it is believed that guar will be a real threat to starch at a somewhat more competitive price, possibly $0.23 to $0.25 per lb. Locust bean gum also has superior properties, but is selling for $0.35 to $0.40 per lb.

Urea-formaldehyde, melamine, and polyamide resins, though added to the paper primarily to increase wet strength, have the incidental effect of increasing dry bonding.

The principal property papermakers would like to see developed in fiber bonding agents is sufficient adhesive properties to eliminate the need for beating of the fibers. Such beating impairs certain fiber characteristics and causes additional fiber losses, though necessary at present to obtain adequate fiber bonding.

Beating serves to rupture the thin outer wall of the fibers and to fray the threadlike elements exposed thus producing fibrils. The fibrils being of much smaller diameter than the untreated fiber are more flexible and more capable of matting together. This permits the establishment of many more points of contact between fiber and fiber, which makes for greater strength.

(*b*) Sizes. The function of sizing materials in paper-

Table VIII. Properties of Packaging Papers

(A chart this size could not possibly show all varieties of papers, coatings, treatments, and laminations. Those selected are typical and meant to be indicative of the many values obtainable for packaging uses)

Properties	*Glassine, plain*	*Glassine, lacquered*	*Glassine, waxed*	*Glassine, laminated*	*Greaseproof paper*	*Kraft, plain*	*Extensible paper*	*Pouch paper*	*Polyethylene-coated paper*	*Parchment, vegetable*	*Waxed paper*
					General						
1. Type of material	Supercalendered dense paper from highly refined special pulp	Resinous-coated glassine (heat sealable)	Waxy coatings on glassine	Multiple-ply glassine, waxy laminant	Uncalendered dense paper from hydrated pulp	Paper from sulfate pulp	Unbleached kraft	Supercalendered, dense, opaque, bleached kraft	Kraft paper with polyethylene coating (heat sealable)	Acid-treated cellulose	Thin calendered paper with waxy coating
2. Forms available	Sheets, rolls	Sheets, rolls	Sheets, rolls	Sheets, rolls	Sheets, rolls	Sheets, rolls	Rolls	Sheets, rolls	Sheets, rolls	Sheets, rolls	Sheets, rolls
3. Clarity	Transparent to opaque	Transparent to opaque	Transparent to opaque	Translucent to opaque	Translucent to opaque	Opaque	Opaque	Opaque	Opaque	Translucent to opaque	Transparent to opaque
4. Thickness range, in.	0.00075 to 0.003	0.00085 to 0.003	0.0009 to 0.003	0.0025 and up	0.001 to 0.004	0.002 to 0.009	0.0025 to 0.011	0.0012 to 0.004	0.002 to 0.030	0.0017 to 0.0065 (single)	0.002 to 0.008
5. Maximum width, in.[a]	90	52	70	80	160	120	230	160	120	90	60
6. Basis weight, lb.[b]	14 to 60	23 to 45	23 to 65	40 and up	14 to 60	20 to 100	30 to 100	20 to 60	Nearly any weight can be obtained [g]	18 to 110	22 to 100
7. Yield, sq. in./lb.	7,200 to 30,857	9,600 to 18,782	6,600 to 18,782	10,800 and less	7,200 to 30,857	4,320 to 21,600	. . .	7,200 to 21,600		3,927 to 24,000	4,000 to 20,000
					Physical						
8. Tensile strength, lb./width	[e]				10 and up	MD, 60–80; CD, 30–40 (% b.w.)	Lower than regular kraft	[e]	To 10% increase over base kraft	High wet strength	10 and up
9. Elongation, %	[e]			[e]	. . .	1.5% MD, 3.0% CD	MD 9%+, CD 4%+	[e]	2 to 5%	MD, 2 to 4%; CD, 4 to 15%	2 to 5%
10. Bursting strength (Mullen), lb./sq. in.	50% or more of basis weight	50% or more of basis weight	50% or more of basis weight	50% or more of basis weight	50% or more of basis weight	70% or more of basis weight	Equal to regular kraft	60% or more of basis weight	To 10% increase over base kraft	13 to 65 dry: good values wet	50% or more of basis weight
11. Tearing strength (Elmendorf), gm.	Better than 50% of basis weight	Better than 50% of basis weight	Better than 50% of basis weight	Better than 50% of basis weight	Better than 50% of basis weight	2–2.5 gm./lb. of basis weight	Higher than regular kraft	Better than 75% of basis weight	To 20% increase over base kraft	Sulfites, 60–80% of b.w. Sulfates, 100–130% of b.w.	1.5 gm./lb. of basis weight
					Chemical						
12. Water-vapor permeability gm./24 hr./100 sq. in. at 100°F., 90% R.H.	High	0.2 and up	0.2 and up	0.3 and up[f]	High	High	High	High	0.3 and up	High if not specially treated	0.3 or more
13. Resistance to flavors, odors, gases	Good	Very good	Very good	Very good	Fair	Poor	Poor	Poor	Fair	Good	Poor
14. Resistance to mild acids, alkalies	Good	Good	Good	Good	Good	Poor	Fair	Good	Excellent	Good	Good
15. Resistance to greases and oils	Very good	Excellent	Very good	Excellent	Very good	Poor	Fair	Poor	Fair	Fair to excellent	Poor
					Permanence						
16. Resistance to heat (limiting temperature), °F.	[c]	150	120	120	[c]	300	260 when dry; any temperature, wet	[c]	200	200 when dry; any temperature, wet	100 to 120
17. Resistance to cold (limiting temperature), °F.	Depends upon use of plasticizer	Depends upon use of plasticizer	Depends upon use of plasticizer	Depends upon use of plasticizer	Depends upon use of plasticizer	Very low limiting temperature	Excellent	Depends upon use of plasticizer	−65	Dependent upon use of plasticizer	0
18. Resistance to sunlight	Good	Fair	Fair	Fair	Good	Fair	Fair	Good	Good	Good	Good
19. Dimensional change at high R.H., %	High	Moderate	Moderate	High	High	MD approx. 0.5; CD approx. 1.5	Moderate	High	Moderate (curls)	Amount of change depends on type	Moderate
20. Aging characteristics [c]	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
21. Flammability	Burns readily	Burns readily	Burns readily	Burns readily	Burns readily	Burns readily	Burns readily	Burns readily	Burns readily	Burns readily	Burns readily
22. Converting characteristics [d]	Excellent, but not heat sealable	Excellent	Excellent	Excellent, but not heat sealable	Excellent, but not heat sealable	Excellent, but not heat sealable	Excellent	Excellent, but not heat sealable	Excellent	Excellent, some coated types heat sealable	Excellent

[a] In many instances, maximum widths vary from producer to producer and standard widths may be less than those given here.
[b] Based on a ream of 500 sheets, 24 by 36 in., or 3000 sq. ft.
[c] Properties of all papers are affected by loss in moisture content when stored in dry, warm atmosphere.
[d] A general index of printability, sealability by heat or adhesives, and performance on automatic machines.
[e] Influenced by basis weight and end-use requirements.
[f] Depending on number of plies and laminants.
Yield depends on paper and weight of coatings.
Source: "Modern Packaging Encyclopedia," 1960 issue.

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making is to impart resistance in paper to the penetration of liquids such as aqueous writing inks, nonaqueous printing inks, blood, or just plain water. Some sizing agents, called internal sizes, are added to the fibrous material in the beater. Others are applied to the surface of the already formed paper.

The beater sizes include, in order of importance as to quantity used, rosin size, wax emulsion, asphalt emulsion, and synthetic size (Table IX). The synthetic sizes on the market are mostly chemically modified fatty acids. Present prices for these materials are about \$0.18 per lb. for rosin size, \$0.18 per lb. for wax emulsion, \$0.09 per gal. for asphalt emulsion and \$1.30 per lb. for synthetic size.

Generally speaking, the use of wax emulsions is limited to the replacement of 20 to 40% of the rosin size normally used. Wax emulsions work well for the sizing of asbestos papers, carbonate-filled papers, hanging grade papers, tag, envelope, and milk bottle stock, but other grades, even high-grade writing papers, may be sized with a small amount of wax in combination with rosin size.

Asphalt emulsions are not used for light-colored stocks, due to the discoloring effects of asphalt. However, this material is well accepted for the sizing of container boards, structural boards, and for a number of water-resistant specialties where color is not a factor.

The synthetic sizes have possibilities for finding increased use as a substitute for rosin size. Even though quite high in price, synthetic size is much more efficient than rosin size—1 lb. is said to achieve the same degree of sizing in paper as 8 to 9 lb. of rosin size. Synthetic size prices have remained unchanged for the past 8 years. Competition is expected to grow, however, and force prices down somewhat. Rosin size prices, on the other hand, which fluctuate with the price of rosin, may show an upward pattern due to short supplies and increasing prices of rosin.

2. Wet-strength Resins. The property of wet strength is entirely different from that of sizing. Sizing refers to the rate at which liquid penetrates paper and has no relation to the wet strength, since once water has penetrated into ordinary sized papers, mechanical strength becomes nonexistent. Sizing merely retards, or, with an abundance of size material, prevents the saturation of the paper; whereas, wet strength resins, which may be added either in the beater or to the surface of the paper, increase the bonding between fibers.

Wet strength is a highly useful property in bag, tag, toweling, tissue, blueprint, map papers, paper draperies, frozen wrap, and other papers. At present, paper and paperboard in which wet-strength additives are incorporated comprise from 3 to 4% of the total, or about 1 million tons. Urea-formaldehyde resins account for 70% of the wet-strength additives in use, melamine resins about 15%, and polyamide resins 15%. The polyamide resin is increasing in use at the expense of urea and melamine because of certain superior properties, such as causing less corrosion in the equipment. Only 1 lb. of polyamide is required to achieve the same wet strength properties as 3 lb. of the urea and melamine resins. Polyamide sells for \$0.75 per lb. versus \$0.24 for urea and \$0.35 for melamine resins.

The market for wet-strength paper and board is expected to increase 10% per year, or slightly more than double that of all paper and board. Most of this increase is anticipated in food paper and board, especially master shipping containers for fresh fruit and vegetables.

3. Defoamers. Frequently during the course of the formation of a sheet of paper, foam accumulates, leading to foam spots and poor formation. Ply separation often results in the case of multiply boards.

Foam can be displaced by any substance which is surface active and which displaces the foaming substance from the surface film. Kerosene, pine oil, paraffin oil, sulfonated oils, alcohols (octyl, diisobutyl, amyl, and caprylic), fatty acids, and fatty acid esters and silicones are the principal foam killers used by the paper industry. These range in price from \$0.10 to \$0.75 per lb., kerosene being the least expensive and silicones the most expensive. There are no data indicating the quantities used of individual chemicals, only estimates of the aggregate of all defoamers. At the present time, industry is trending away from the use of petroleum products for the making of food paper and board because of Food and Drug Administration objections. This may augur well for expanded use of natural fats and fatty acids as defoamers. Though more costly than petroleum products, acids are less costly than alcohols or silicones.

4. Surface Sizes. The major sizes applied by surface application to the already-formed paper are, in approximate order of importance, corn, tapioca and potato starches, and animal glue (Table IX). Wheat starch, carboxymethylcellulose, polyvinyl alcohol, and sodium alginate are also used. Surface sizing cements the fibers to the body of the paper and deposits a more or less continuous film on the sheet of paper. It increases resistance to writing and printing inks, improves finish, printability, scuff-resistance, strength, and erasability.

Animal glue forms a more uniform and continuous film than starch. However, because of its relatively high price, \$0.20 to \$0.30 per lb., versus \$0.05 to \$0.07 for starch, animal glue is used principally in making fine papers. Polyvinyl alcohol and carboxymethylcellulose tend to produce a sizing layer which more nearly approaches a continuous film than either starch or animal glue. The present price of polyvinyl alcohol and of highly purified grades of carboxymethylcellulose suitable for surface use is \$0.57 per lb. Sodium alginate is presently priced at \$1.02 per lb.

Because of cost, sodium alginate apparently constitutes little threat to starch as a substitute for surface sizing. Polyvinyl alcohol and carboxymethylcellulose, on the other hand, may eventually have a larger share of the size market if prices continue to decline. The most recent price decrease for polyvinyl alcohol was in 1958 when prices dropped from a 6-year level of \$0.75 per lb. to \$0.57.

Five pounds of polyvinyl alcohol accomplish about the same degree of surface sizing as 18 lb. of starch. Manufacturers of polyvinyl are endeavoring to move into the sizing market by selling the idea of mixing starch and polyvinyl for sizing in a ratio of about 3 or 4 parts starch and 1 part polyvinyl. At present the commercially used mixes range from 20 parts of starch and 1 of polyvinyl to a 1 to 1 ratio. The claim

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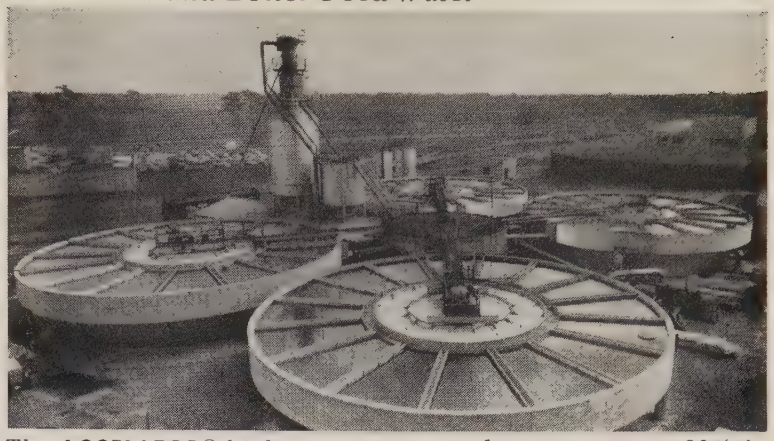

The **ACCELATOR®** high rate treatment plant saves up to 80% in space. It clarifies or softens and stabilizes water in a single basin, and produces more stable effluent — a slurry contact — not a sludge blanket unit. Hot process softeners, Zeolite softeners and demineralization equipment are offered for boiler feedwater treatment. A full line of feeders, pressure filters and equipment for gravity filters including meters, rate controllers, control panels, and operating tables supplements the high rate line. **Bulletin 1825**

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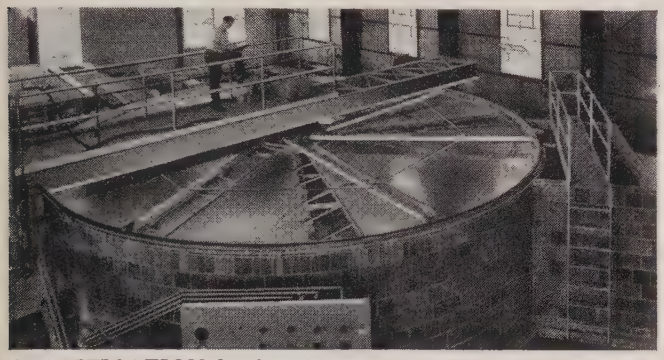
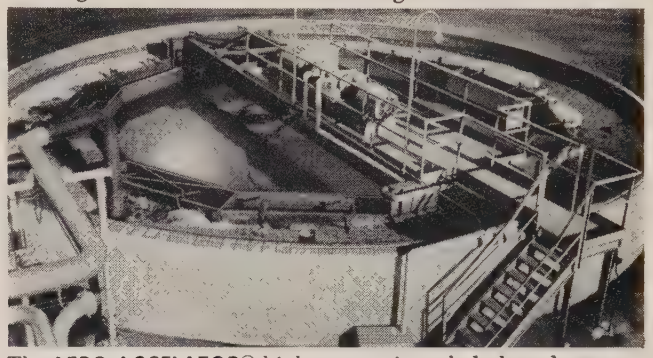


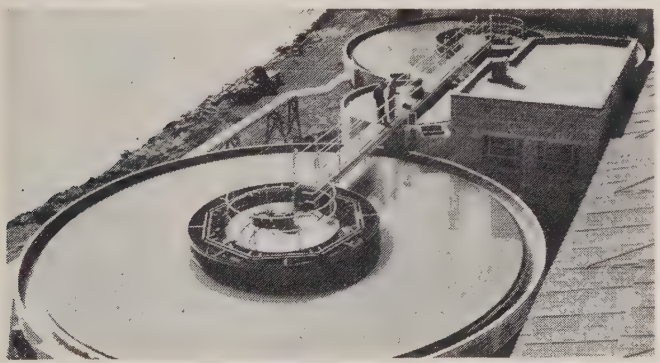
CLARIFICATION *by flotation*

The **SEDIFLOTOR®** clarifier is offered where space is limited and high-rate clarification is essential. This air flotation unit is ideal for removing floatable suspended solids and gives most effective fibre and heat recovery. **Bulletin 6051**

...High Rate Activated Sludge



The **AERO-ACCELATOR®** high rate activated sludge plant provides a multi-purpose unit for BOD reduction. Rapid mixing, biological oxidation and clarification under high loadings are effected within a single basin. **Bulletin 6510-D**



CLARIFICATION *by chemical treatment and settling*

The **CYCLATOR®** clarifier treats wastes containing suspended solids of very fine or colloidal nature which require chemical coagulation for adequate clarification. This unit can provide solids recovery and heat recovery by reuse of the clarified effluent. Sedimentation clarifiers with skimmers and scrapers, are part of the INFILCO line. **Bulletins W-800 and 850**

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These are a few of the products for water and waste treatment in the complete INFILCO line.

Write for our condensed catalog and other bulletins.

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414-60

Table IX. Estimated Consumption of Organic Chemicals In the Manufacture of Paper and Paperboard, 1959

Chemical	Beater additives: Fiber bonding agents	Beater additives: Sizes	Wet-strength resins	Defoamers	Surface sizes	Coatings	Corrugating and laminating	Volume used, tons
Starch, all	..	..	..	..	..	..	..	584,450
Corn[a]	X	..	..	..	X	X	X	445,850
Tapioca[a], *	X	..	..	..	X	X	X	69,850
Potato[a]	X	..	..	..	X	X	..	46,750
Wheat[b]	X	..	..	..	X	X	..	22,000
Gum & Phenolic Resins[b]	X	..	..	..	..	O	O	5,000
Gum Additives (probably mostly guar and locust bean gum)[b]	X	..	..	..	..	..	..	4,600
Rosin[c]	..	X	..	..	..	..	..	147,606
Wax size (emulsion)[b]	..	X	..	..	..	..	..	18,000
Asphalt emulsion[b]	..	X	..	..	..	..	..	10,000
Synthetic size[b], †	..	X	..	..	O	..	..	8,000
Urea resin[e]	..	..	X	..	..	..	..	12,549
Melamine resin[e]	..	..	X	..	..	..	..	2,688
Polyamide resin[b]	..	..	X	..	..	..	..	2,688
Defoamers[b] (includes glycerol esters, fatty acids, kerosene and fuel oil)	..	..	..	X	..	..	..	7,900
Urea-formaldehyde[b], ‡	..	..	..	..	X	..	..	7,500
Sodium alginate[b]	..	..	..	..	X	..	..	950
Carboxymethyl-cellulose[b]	..	..	..	..	X	..	..	300
Paraffin waxes and wax derivatives[b]	..	..	..	..	..	X	..	77,000
Casein[d]	..	..	..	..	..	X	..	28,000
Animal glue[b]	..	..	..	..	O	X	..	21,900
Latices[b]	..	..	..	..	..	X	O	11,000
Soybean protein[b]	O	..	..	..	..	X	..	4,600
Vegetable oil[b]	..	..	..	..	..	X	..	1,400
Glycerine[b]	..	..	..	..	..	X	..	1,200
Vinyl resins[f]	..	..	..	..	..	X	..	32,350
Styrene resins[f]	..	..	..	..	..	X	..	30,390
Acrylic resins[b]	..	..	..	..	..	X	..	290
Dextrine[b]	..	..	..	..	..	..	X	170
Total								1,020,531
Sodium silicate[b], §	..	..	..	..	..	..	X	17,000

Note: X indicates principal use; O indicates minor use.

[a] Estimated from data included in "Starch" U. S. Tariff Commission, March 1960.

[b] Estimated from data included in "The Market for Chemicals in the Pulp and Paper Industry, 1960" Paper Trade Journal, Market Research Panel Report, 1959.

[c] From "Agricultural Statistics" 1955, 1956, and 1957 issues, U. S. Department of Agriculture, and "1959–60 Annual Report, Production, Supply, Distribution and Stocks of Turpentine and Rosin and Related Data for the United States" May 1960.

[d] Represents 60% of available supply (mostly imports). This estimate of the proportion of available casein used in paper and board manufacture taken from comments by industry representatives included in a Congressional hearing report entitled, "Extension of Suspension of Duty on Imports of Casein," March 31, 1960.

[e] Estimated from data included in Facts for Industry Series 6-10-134, U. S. Tariff Commission, March 22, 1960, and data assembled from personal interviews with paper chemical suppliers.

[f] Facts for Industry Series 6-10-134, U. S. Tariff Commission, March 22, 1960. Data shown are identified as "Textile and Paper Treating and Coating."

* Imported: Includes small quantities of imported corn and potato starches.

† Probably includes chemically modified fatty acids for beater sizing and polyvinyl alcohol for surface sizing.

‡ Added to starch where insolubility is desired.

§ An inorganic chemical. Included because it is competitive with starch in corrugating and laminating.

is that the special properties of both materials are largely retained—starch for extra thickness and scuff-proofness and polyvinyl for better printability, strength, film forming properties, and pigment brightness.

Carboxymethylcellulose and alginate manufacturers indicate that the most marketable special properties of those materials are "holdout" and increased resistance to oil and grease. Maximum coverage is obtained in surface application because of less tendency to penetrate the paper or board and good gloss results in printing with a minimum of ink.

5. Coatings. (a) Pigment Coatings. Pigment coating is an aqueous mixture of pigment and adhesive which is applied to the surface of the paper. This type of coating is used primarily for the production of printing papers for magazines and catalogs.

The principal pigments used are inorganic materials such as clay. The chief coating adhesives are starch, casein, soybean protein, animal glue, and synthetic latices. Small quantities of acrylics and polyvinyl alcohol are also used. The functions of the adhesives are (1) to serve as a carrier for the pigment so that the coating mixture will have the proper flow properties, (2) to bond pigment particles together in the dried coating and to bond the pigment to the body stock, and (3) to control the absorption of printing ink during printing of the coated paper.

The proteins (casein, soybean protein, and animal glue) are used for the coating of high-grade papers

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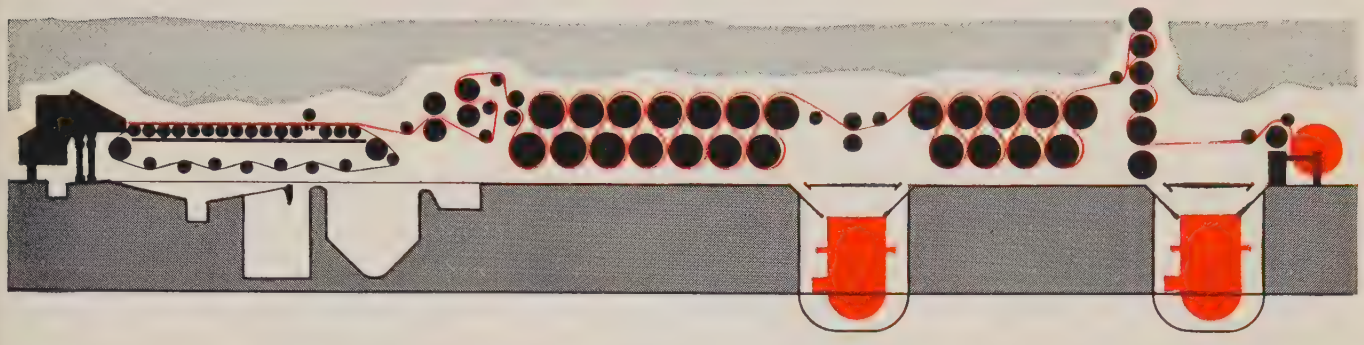

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Table X. Properties of Protective Packaging Coatings

Coating material	Base material	Wt., lb./3000 sq. ft., reams: Coating	Base	Total	Heat-seal range, °F. (reciprocating jaw, 0.5-sec. dwell)	Water-vapor permeability at 100°F., 90% R.H. increased, g./100 sq. in./24 hr.	Grease[a] resistance
Wax coatings							
Refined paraffin wax	MF[b] sulfite	5	25	30	...	High	Poor to fair
	SC[b] sulfite	10	25	35	150–180	0.7–2.0	Fair
	Glassine	4	25	29	150–180	0.2–0.4	Good
	Glassine	6	25	31	150–180	0.1–0.2	Good
Modified paraffin wax	SC sulfite	10	25	35	150–180	0.7–2.0	Fair
	Glassine	8	25	33	150–180	0.1–0.2	Good
Hot-melt types	SC sulfite	10	25	35	200–350	High	Fair
Solvent coatings	SC kraft	8	32	40	200–300	0.8–1.2	Good
Cellulose nitrate	Glassine	3	22	25	200–300	0.4–0.8	Good
	Cellophane	2	20	22	200–300	0.2–1.0	Good
Cyclized rubber	SC kraft	8	32	40	200–300	0.6–1.0	Fair
	Glassine	3	22	25	200–300	0.15–0.25	Good
Butadiene-styrene	Glassine	3	22	25	200–300	0.15–0.25	Good
Vinyl copolymers	SC kraft	5	25	30	220–280	4.0–6.0	Good
	Glassine	3	22	25	220–280	2.0–5.0	Good
Vinylidene chloride	SC kraft[c]	6	25	31	250–300	2.0–3.0	Good
(Saran-type)	Glassine[c]	4	25	29	250–300	1.0–2.0	Very good
	Cellophane	4	20	24	250–300	0.5–0.7	Very good
Extruded coatings							
Polyethylene							
Low density 0.5 mil	MF or SC kraft	8	25	33	200–300	2.5–3.5	Fair
Low density 1.0 mil	MF or SC kraft	15	25	40	200–300	1.2–1.6	Good
Low density 2.0 mil	MF or SC kraft	30	25	55	200–300	0.6–0.8	Very good
Low density 0.5 mil	Foil-glassine	8	42	50	200–300	Less than 0.02	Excellent
Low density 2.0 mil	Cellophane	30	24	54	200–300	0.5–0.7	Excellent
Med. density 1.0 mil	SC kraft	15	25	40	200–300	0.6–0.8	Good

[a] Depends on type of grease and other factors.
[b] MF = machine finish; SC = supercalendered.
[c] Experimental at present.
Source: "Modern Packaging Encyclopedia," 1960 issue.

and papers in which a high degree of water resistance is desired. It is more difficult to achieve water insolubility in starch than in the proteins. Latices are generally not practical as the only adhesive, but are useful in blends with casein, glue, and soy protein. The latices improve the smoothness, gloss, flexibility, and wet rub resistance of the coating. The interest in polyvinyl among papermakers stems from the reduction in the volume of adhesive required, thereby making the pigmenting operation easier. Apparently less pigment is required to obtain the same color or brightness objective.

The current price for synthetic latex is $0.29 per lb. compared to $0.20 to $0.30 for animal glue, $0.20 for casein, $0.23 for alpha soybean protein, and $0.20 for delta soybean protein. Soybean protein and casein are generally interchangeable as a pigment binder and the determination of which material is used is largely one of price. However, soybean protein is preferred for high solids coatings and casein where water resistance is important. At the present time almost all of the casein is imported, primarily from the Argentine.

(b) Resin and Wax Coatings. Papers coated with resins and wax are used primarily for wrapping and packaging where the function of the paper is to protect the contents. The base paper may be either supercalendered sulfite, kraft, glassine, or cellophane. Coated papers are also sometimes used for their improved appearance, such as coated fancy box papers.

Coated wrapping papers have many advantages over uncoated wrapping papers because several different functional properties can be combined in a single sheet of coated paper. For example, uncoated glassine has good physical strength and a high degree of water resistance but is not resistant to water vapor. Coated glassine has the desirable properties of the uncoated product and, in addition, is quite resistant to water vapor.

The coating may be either a lacquer, an aqueous dispersion, an emulsion, latex, organosol, plastisol, a hot melt, or extruded polyethylene. The properties of a number of important protective coatings are shown on Table X.

There are not sufficient secondary data available to appraise the economics of using the various coatings.

6. Corrugating and Laminating. The operations of laminating, combining, gluing, and pasting are important parts of the paper industry. These involve the sticking together of two or more sheets of paper by means of a laminant, or glue, with the purpose of producing either increased strength, improved appearance, or greater utility in some other respect, such as reducing permeability to vapors or gases. The types of adhesives used in laminating paper include (1) aqueous adhesives such as animal glue, starch, sodium silicate, and casein, (2) hot melt adhesives such as wax, and (3) lacquer type adhesives. The chief adhesives presently in use are starch and sodium silicate. Close to 25% or 100,000 tons, of the corn starch used by the paper industry was employed in corrugating and laminating in 1959. The present price of sodium silicate, $0.068 per lb., is about competitive with the price of starch.

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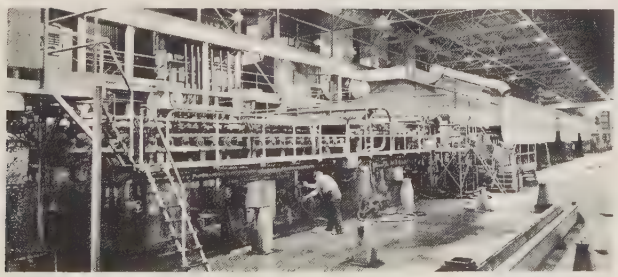

New 246″ Kraft paper machine at Halifax Paper Company, Inc. has boosted the mill's total daily production of Kraft paper to over 600 tons per day. The new No. 4 machine — the "Dixie Queen" — operates next to the "Southern Star," a sister 246″ Beloit machine installed in 1953. For further details, please turn the page.

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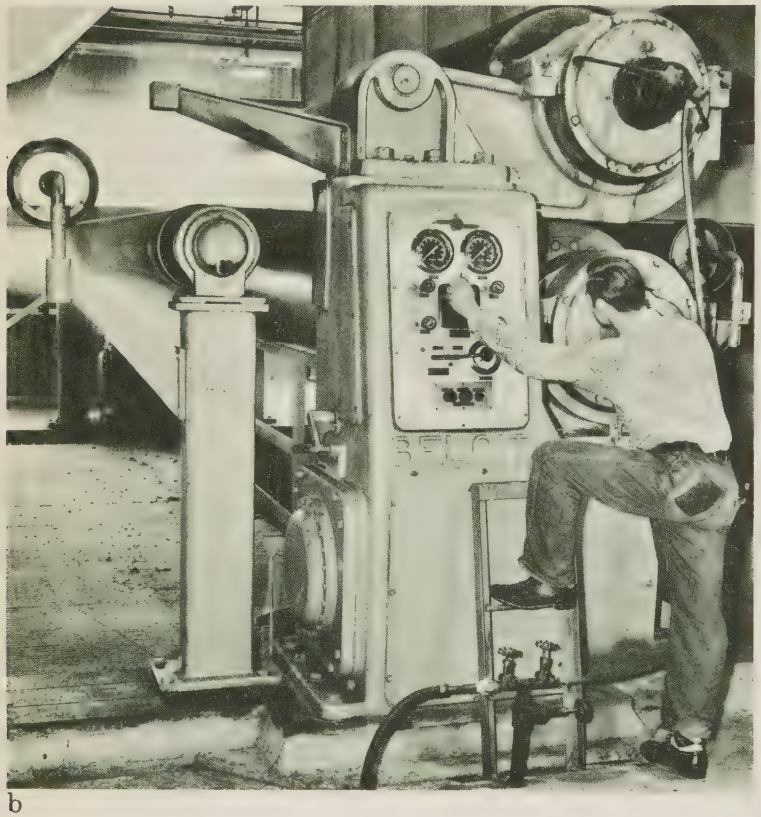
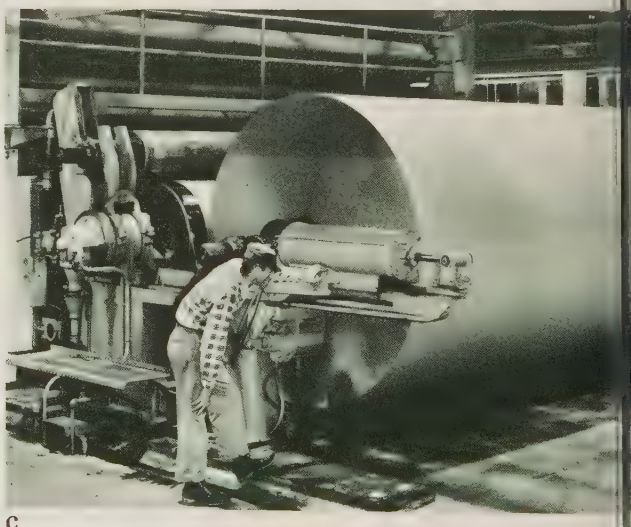


b

The "Dixie Queen," new 246" Kraft paper machine at Halifax Paper Company, Inc.

The "Dixie Queen" was running at speeds up to 1200 fpm within 72 hours and salable paper was produced six hours after start-up. The Fourdrinier and dryer sections are arranged to permit future expansion of productive capacity. (**a**) 246″ Beloit removable Fourdrinier and Type E air-cushioned inlet. (**b**) Breaker stack equipped with air-operated nip pressure control. (**c**) Beloit heavy-duty Kraft-type pneumatic reel. (**d**) Straight-through suction press with open couch draw.



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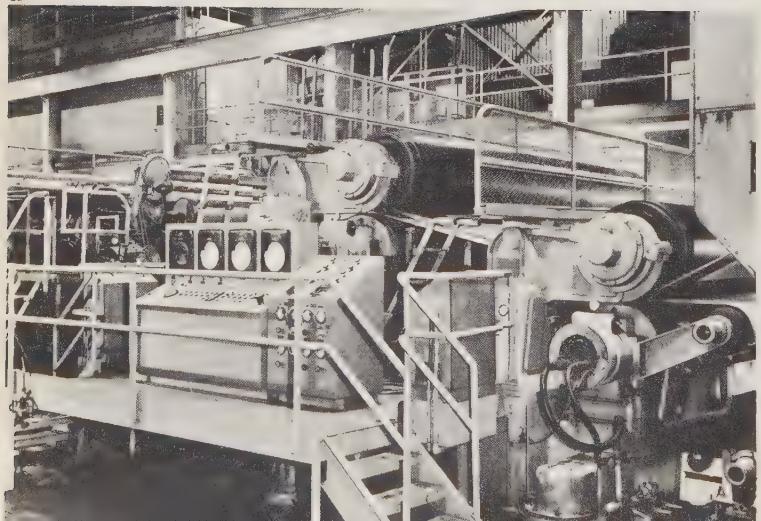

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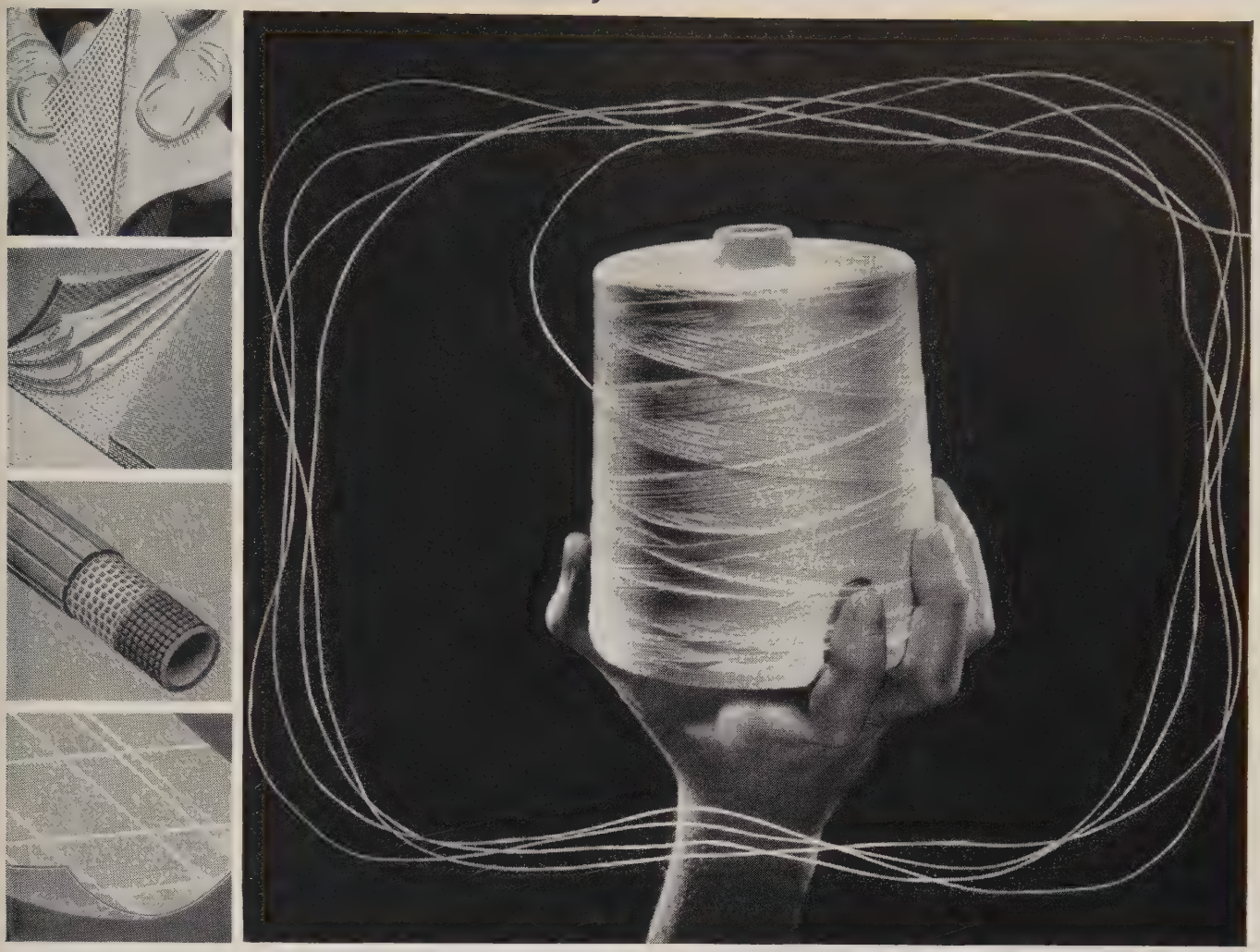

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Pulpwood Properties: Response of Processing and of Paper Quality to Their Variation*

FOREST BIOLOGY SUBCOMMITTEE NO. 2 ON TESTS AND QUALITY OBJECTIVES

A. INTRODUCTION

Occasion and Objective

UNTIL very recently, there has been little technical interchange between the foresters and forest scientists who are growing and seeking to improve trees for use as pulpwood, and the scientists of the pulp and paper industry who are conversant with the fiber properties and behaviors which are fundamental in pulping and papermaking. During the past few years, however, the kinds of activity in which the industry has engaged to meet the steadily increasing demand for more and higher quality pulpwood have made it imperative for foresters and papermakers to establish liaison, trade information and points of view, and plan cooperatively.

Especially is it vital that foresters and forest scientists, having some opportunity to manipulate both environmental and genetic circumstances of wood growth, understand which of the variable properties of the raw material are of significance to the papermaker because of their reflections in processing and their effects upon the properties of the paper product. We are now quite confident that some of these properties of wood and wood fiber can be sufficiently altered by the silviculturist or geneticist to justify application, through establishment and culture of forest stands, of existing information about raw material effects which pulping and papermaking scientists could furnish.

The aim of the present report is to aid in orienting programs devoted to these objectives by providing a digest of current information on 13 significant pulpwood properties, viewed as variables whose effects are registered in terms of (1) the facility and economy of the industry's processing and (2) properties of the resulting pulp or paper product. No specific reference is made to evaluation of wood as timber. It is generally agreed that most characteristics which are desirable in pulpwood would also be desirable in timber. There are exceptions, however, and the possibility of utilization for either purpose should be kept in mind.

Familiarity with the pulpwood property information presented in this report will not solve all of the problems of the forest biologist who wants to know what wood properties to emphasize in a tree improvement program. This is a decision which depends also upon the circumstances of the particular operation. Ordinarily, it should be reached by pooling the judgment of persons well qualified to represent each major operating and background consideration. One of the difficulties here, of course, is that one of these "well qualified" people should be a seer who can predict today the kinds of processing considerations and paper properties which will be relevant 25 or more years hence! Some requirements which are basic now may, however, continue to be basic. Developments of the next 5 or 10 years conceivably may also make it easier to discern future trends.

There is also an important proviso on the biological side which must be appreciated. The forest biologist and forest manager who seek to improve the quality of the pulpwood they grow are not yet in a position to apply more than a few of the wood property recommendations offered to them by the pulp and paper scientist. This is because of the inadequacy of present information about (1) the heritability (a quantitative expression of the transmissibility, through seed, to the next generation of trees) of wood properties, and about (2) the kind and degree of influence upon wood properties which can be achieved through practical control of environmental factors.

Concerning heritability, the evidence for wood density, fiber length, and fibrillar angle in certain conifers is encouraging, and some of the first indications in hardwood species are favorable, but thoroughly satisfactory estimates of heritability are mostly yet to come.

As to environmental factors, it is encouraging to note substantial recent progress in forest land site evaluation and the demonstration of several environmental factor-wood property correlations. Latitude-related environmental factors appear also to have significant wood property effects in certain instances.

Accumulation of data on heritability and on the nature and magnitude of environmental factor effects has thus a high priority in the long continuing research program which is needed to show the way in tree and stand improvement for better pulpwood quality.

It is probably not too much to claim that even today we are in a position to avoid making serious errors in planning, if our current wood quality decisions for commercial scale application are, in the main, conservative. The long term prospect for practical partial biological control over some wood properties appears promising.

Definitions

In Section B of this report, the term "density," closely related to specific gravity, always refers to pounds of ovendry weight per cubic foot volume when green, or in the metric system, grams of ovendry weight per cubic centimeter of green volume. Wood substance itself varies but little in density. Since the values recorded for a given wood therefore depend almost entirely upon what fraction of the volume is pore space, some workers

* Progress Report 1, TAPPI Project 697, submitted by the Forest Biology Committee, prepared by its Subcommittee No. 2, on Tests and Quality Objectives, and edited by its chairman, Philip N. Joranson. Approved for presentation at the TAPPI Forest Biology Conference held Aug. 24 to 26, 1960, in Seattle, Wash.

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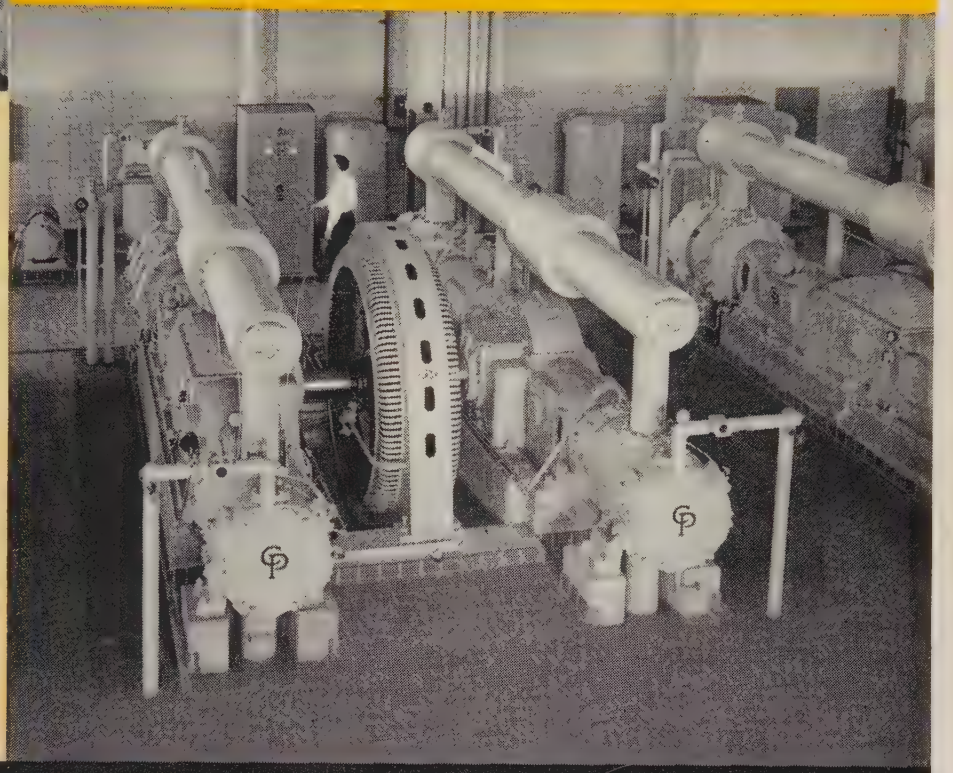

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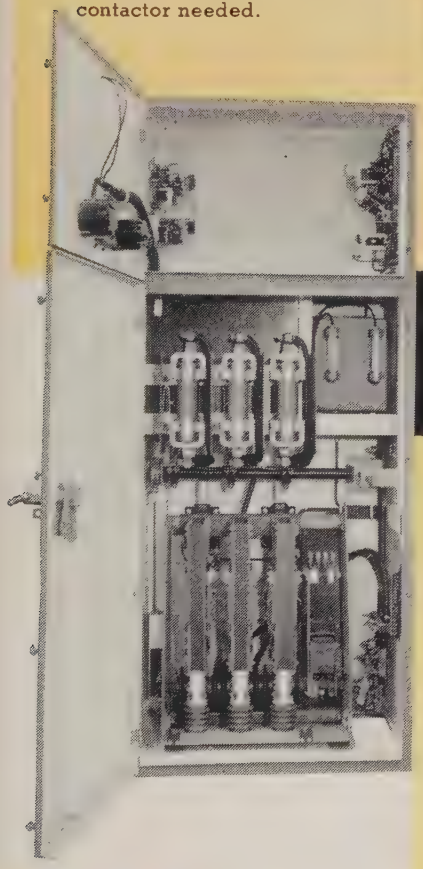

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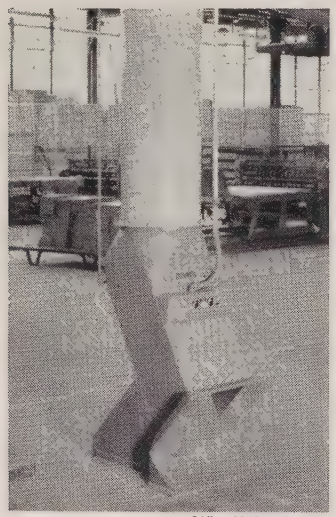

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have preferred the term "apparent density," in recognition of this fact. In this report, though the commoner term "density" is used, it should be understood as apparent density. The term "closeness of grain," commonly used by some wood technologists, is not synonymous with density.

The term "pulp yield," except where otherwise specifically noted, expresses the ovendry weight of pulp produced, as a percentage of the ovendry *weight* of the wood.

"Fiber" is used in the generalized sense, referring both to the tracheids of conifers and to the fiber tracheids and libriform fibers of hardwoods. Other morphological terms essentially follow the usage of the International Glossary of Terms Used in Wood Anatomy (*Tropical Woods*, No. 107, Oct., 1957, pp. 1–36), and technical terms of pulping and papermaking which occur are used essentially as defined in "The Dictionary of Paper," second edition. American Paper and Pulp Association, N. Y., 1951.

B. INFLUENCES OF THIRTEEN PULPWOOD PROPERTIES IN PULP AND PAPER PROCESSING AND UPON SHEET PROPERTIES

1. Density

Pulp yield and pulp quality are both influenced by wood density. The effect of density on pulp yield, however, must be further qualified. When pulp yield by a particular process is expressed in the usual way as a percentage of wood *weight*, no prominent effect has been found with varying density within a species (but see Section 12, *re* yield from tension wood.) Yield per unit *volume* of wood, on the other hand, is directly related to the density of the wood, and this relationship accounts for most of the variation in volume basis yield within a particular species.

Variation in density also reflects variation in cell structure, particularly cell-wall thickness, within a species. Consequently, in contrast to wood of low density, high-density wood tends to yield pulps characterized by high resistance to beating, high bulk, high tearing strength, low tensile and bursting strengths, and low folding endurance. These relationships are prob-

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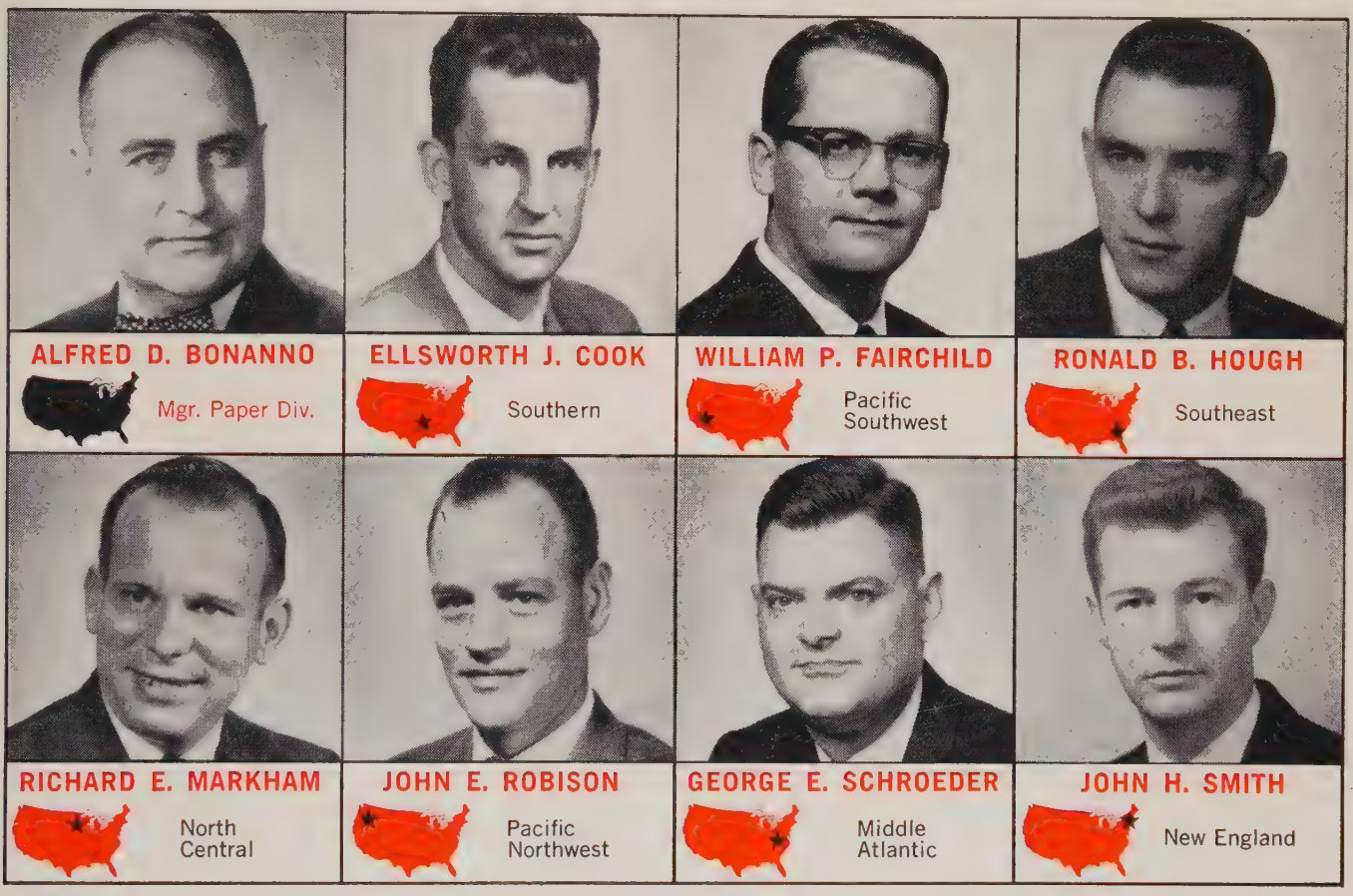

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ably best exemplified in the case of conifers with relatively distinct zones of low-density springwood and high-density summerwood.

In tree improvement programs it should also be considered that, in individual mature trees, high density may be due to high extractive content. Thus, high extractive content may contribute to high density, but not to pulp yield. (See also Section 4—Chemical Composition of Wood, paragraphs 7 and 8.)

2. *Proportion of Springwood and Summerwood*

The importance of this factor obviously depends upon recognizable differences between springwood and summerwood, and is therefore of significance mainly in certain coniferous species. Some differences, for example in fiber wall thickness, fiber width, and fiber strength, have been observed, but to varying degrees, among different species.

The relationship of springwood and summerwood content to the use of wood in the pulp and paper industry is summarized as follows:

Pulp Yield. High summerwood content is usually associated with high wood density and resulting high pulp yield per unit volume. In addition, the lower percentage of lignin in summerwood appears to give a slightly higher yield per unit weight of wood when it is pulped to a given lignin content.

Processability. The response of fibers to purification in pulping and bleaching processes is probably related to fiber cross-sectional dimensions, therefore to springwood/summerwood ratio. The ratio of cell wall thickness to cell lumen diameter desired may not be the same for a hardwood as for a coniferous species. The average ratio may vary greatly among individuals of the same species.

Pulp Properties. High springwood content gives high bursting strength (Mullen), tensile strength, and folding endurance, low tearing strength, low bulk, smooth surface, and low beating power requirement, relative to results from wood of the same species having high summerwood content. Under some refining conditions, considerable fibrillation and hydration of springwood fibers can occur with little effect on summerwood fibers being noted.

Performance of dissolving pulps is affected by the physical properties of individual fibers and of the pulp sheet. Fiber dimensions are thus an important consideration.

These observations indicate the importance of a knowledge of factors controlling the springwood/summerwood ratio. They do not, however, suggest specifications for an "ideal" ratio. Preference for high versus low springwood content will depend upon specific use requirements. For uses where high springwood content gives desirable pulp properties, it would be especially valuable to escape the usual relationship of low density with high springwood content. Isolated cases of trees with high springwood content *and* high density have been found.

3. *Growth Rate*

Rate of growth, measured as number of rings per inch of radius on the cross section of wood, has long been considered to be closely related to wood density. Although much emphasis has been placed on rate of growth, serious limitations on its usefulness as a measure of wood density are now recognized.

An appreciable part of the density variation that has been attributed to width of growth ring is in reality associated with age of wood outward from the pith. In a number of softwoods, at least, the wood laid down near the pith is characteristically both wider ringed and lower in density than the mature wood produced later in the life of the tree, at the same height in the tree. This has led to an apparent cause and effect relationship with growth rate.

When compared at the same age of tree, however, ring width has been found to have relatively little independent influence upon either the density of wood or the percentage of summerwood. To what extent this can be accepted as a generalization for all species or all conditions of growth is not known.

Much more study is needed of the influence of site, environment and genetic factors on the growth of wood and on the quality of its fiber.

4. *Chemical Composition of Wood*

Analyses for the following constituents are presently the most significant means of characterizing wood chemically: (a) lignin, (b) holocellulose, (c) alpha-cellulose, (d) pentosans, (e) 1% NaOH solubles, (f) alcohol-benzene solubles, and (g) hot-water solubles.

Interpretation. Lignin content of North American trees ranges between 18 and 34%. Some hybrid aspen has been reported to have higher lignin content (21.6%) than normal aspen (17.5 to 18.5%). Since one objective in most pulping processes is removal of lignin, it is obvious that low lignin in wood is desirable. Lower wood lignin content produces higher yield of cellulose fibers based on wood weight and also on digester volume—will also require less pulping and bleaching chemicals.

Holocellulose is essentially alpha-cellulose plus hemicellullose.

Alpha-cellulose is the only wood component desired for dissolving pulp and the primary strength-producing component in paper pulp.

Hemicellulose, of which pentosans are a part, is important as a bonding, swelling and plasticizing agent in papermaking.

1% NaOH solubles is indicative of low molecular weight material and of the content of rot in wood and should therefore be low.

Alcohol-benzene solubles, which can range from 0.5 to over 5% are undesirable wood components, some of which cause difficulties in papermaking (pitch), and others of which interfere with sulfite pulping ("phenolics" in Douglas-fir and pine heartwood). Some of these extractives have market value, but if not removed they may be a source of difficulty in pulping or papermaking.

Hot-water solubles are undesirable if present in quantities, because of effect on chemical consumption and pulp yield.

In summary: Chemical composition of wood for paper pulp and dissolving pulp indicates improvement over standard when a, e, f, and g are lower. In paper pulp, b and c should be higher than standard; in dissolving pulp c should be higher than standard.

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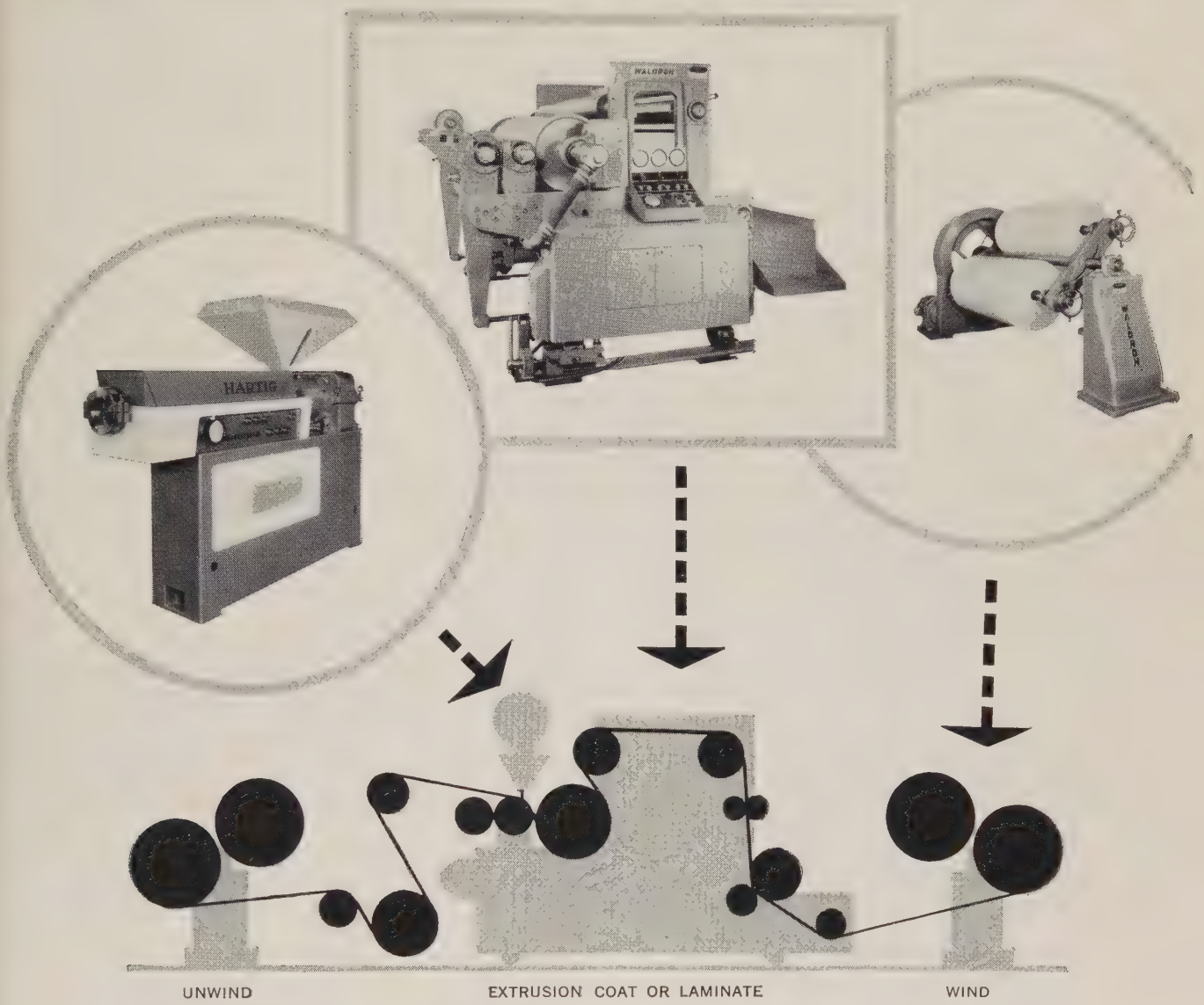

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5. *Fiber Length (Average and Distribution)*

Fiber length influences most pulp strength characteristics, but it should be noted that all fiber dimensions (length, diameter, and wall thickness) are interdependent in a complex and little understood way, and influence many aspects of papermaking.

Beside pulp strength, the fiber-length distribution is important to the response of unrefined pulp to washing and screening operations. Longer fibers wash more easily, but screen with more difficulty.

It is generally thought that long fiber length is desirable for paper strength, except where there is a detrimental effect on sheet formation. Longer average fiber length is generally accompanied by higher tear resistance, and to a lesser extent, by an increase in burst, tensile, and fold. The longer fibers provide a greater area over which applied stress is distributed and, therefore, greater stress can be tolerated.

Southern pines are an example of long-fibered woods, having average whole fiber lengths varying mostly from 2.5 to about 4.2 mm. While fiber lengths in the upper part of this range are of importance to coarse papers or functional papers requiring high tear resistance, many paper grades designed for printing require considerable fiber shortening on refining for the paper machine, in the interests of good sheet formation. While fiber length and length distribution are important, it is possible to control the length and distribution by blending longer or shorter fibers taken from differing wood species, or by refining. It has appeared, therefore, that except for papers requiring very high tear resistance, the current production average fiber length in southern pine pulpwood is sufficient for most paper requirements, and that a longer fiber would be a handicap to many papers produced for printing purposes. Recent thinking, however, has inclined some southern pine pulp producers to favor at least moderate increase in fiber length. It is possible that this might be justified by an associated favorable effect on strength properties other than tear, and by some evidence that per cent alpha-cellulose increases as fiber length increases.

In northern spruce species, there is perhaps little or no justification for attempting to increase fiber length in order to enhance paper strength by creating more bonds between fibers, but as just suggested for southern pine, other possible favorable effects associated with fiber length might deserve attention.

In contrast with the conifers, hardwoods are classed as short-fibered woods, with fiber lengths varying from 0.6 to 1.8 mm., and generally yield papers having lower tearing resistance. It may be desirable in many of the shorter hardwoods to increase fiber length by genetic means.

6. *Fiber Diameter*

Fiber diameter, at a given wall thickness, influences the behavior of pulps in washing, screening, and refining operations, and has an important effect on sheet formation, fiber bonding, fiber rigidity, and mobility. At present there does not appear to be a quantitative understanding of the relationships.

In general, however, it is felt that small-diameter, thin-walled fibers are desirable for good formation and strength, compared to large-diameter fibers. Again it should be noted that all fiber dimensions (length, diameter, and wall thickness) are interdependent in a complex way in their effect on aspects of papermaking. Such factors as the effect of fiber diameter on bonding and sheet density are not clearly established, but undoubtedly fiber diameter is important.

7. *Cell Wall Thickness*

Cell wall thickness is a very important factor in determining the papermaking characteristics of fibers. In general, thicker walls tend to give: (a) higher volume basis pulp yield, (b) coarse, bulky sheets, (c) an increase in tear resistance, (d) generally rougher sheet surface, and (e) a decrease in burst, tensile, and fold.

8. *Fibrillar Angle*

The fibrillar angle is the plane acute angle between the direction of the longitudinal axis of a fiber and the direction of the fibrils in a particular fiber cell wall. Generally, the fibrillar angle of the central layer of the secondary wall is the most important one, because this layer contains most of the cellulose, and hence is the angle usually considered.

Fibrillar angle has been found to be correlated in some cases with wood strength. Although much more work needs to be done to verify the effect of fibrillar angle on paper strength, it is believed that small angles are associated with higher fiber strength, which in turn (other things being equal) is associated with higher tear and tensile-related strength.

Fibrillar angle has also been found to be inversely related to tracheid length in some conifers.

9. *Fiber Strength as it Exists in the Wood*

The strength of individual fibers in a sheet of paper can contribute significantly to the strength properties of the paper. The extent of this contribution depends upon the degree of fiber bonding in the sheet, since lightly bonded fibers will separate from each other long before the fibers themselves are stressed to the point of failure.

Fibers may be reduced in strength in a number of ways in the pulping and papermaking operation, most notably in the pulping and bleaching steps. Even the most selective laboratory procedures for isolating fibers from wood have been shown to produce some attack on the fiber. Very little is known about the strength of fibers as they exist in the wood and how much of this strength is lost in separating the fibers in commercial pulping operations. However, there is evidence that the strength per unit weight will tend to increase as the nonfibrillar wood components are dissolved away. Again, very little is known about inherent differences which may exist between the strength of fibers from different types of wood. Chemical studies, however, have shown that there are substantial differences in the ease with which different woods can be delignified.

Selective removal of lignin to preserve the strength of the cellulosic structure of the fiber is essentially a pulping or bleaching problem. However, the strength of the fiber as it originally exists in the wood and the accessibility of the wood to pulping liquors would appear to be of genetic interest. The stronger the fiber is in its original condition in the wood, and

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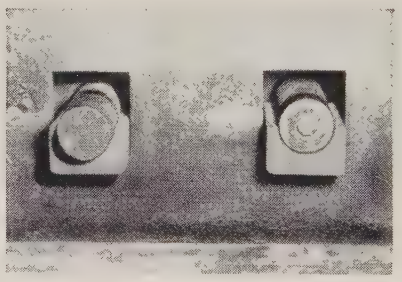

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10. Bonding Strength—Fiber-to-Fiber

While the fiber-to-fiber bonding strength obtained in a heet of paper is doubtless strongly affected by the wood raw material employed, it is a stronger function, usually, of the chemical and mechanical processing which the fiber has undergone in its long path from the forest to a sheet of paper.

It is generally believed that the variation in fiber-to-fiber bonding characteristics displayed by papermaking fibers from different sources is a function both of chemical composition of the fiber, and of fiber dimensions. It is widely believed that the *chemical characteristics* which establish fiber-to-fiber bonding involve not only the absolute amounts of pentose and hexose polymers, but the proportion of these and the distribution of these through the fiber wall. Inasmuch as a redistribution of these, as well as a change in amounts and proportion, may occur during any process which separates the fibers from the wood, this loss has been an extremely difficult matter to pin down. We do know that fibers of higher hemicellulose content will give relatively greater bonding because of possible "cementing" and swelling actions. The optimum quantity of, and balance among, the various pentose and hexose polymers is not known, but there are strong indications that "pentosans" are *not* the sole chemical agents responsible for bonding.

As regards *fiber dimensions*, we do know that fibers with relatively thin cell walls will tend to produce relatively higher fiber-to-fiber bonding, presumably because of their greater conformability.

11. Knotwood

Knotwood is generally rather dense and, hence, increases the density of wood. The response of knotwood to pulping is dependent on the pulping process. In general, however, it does not respond well to pulping and may increase screening rejects, thereby decreasing screened pulp yield, and is therefore undesirable.

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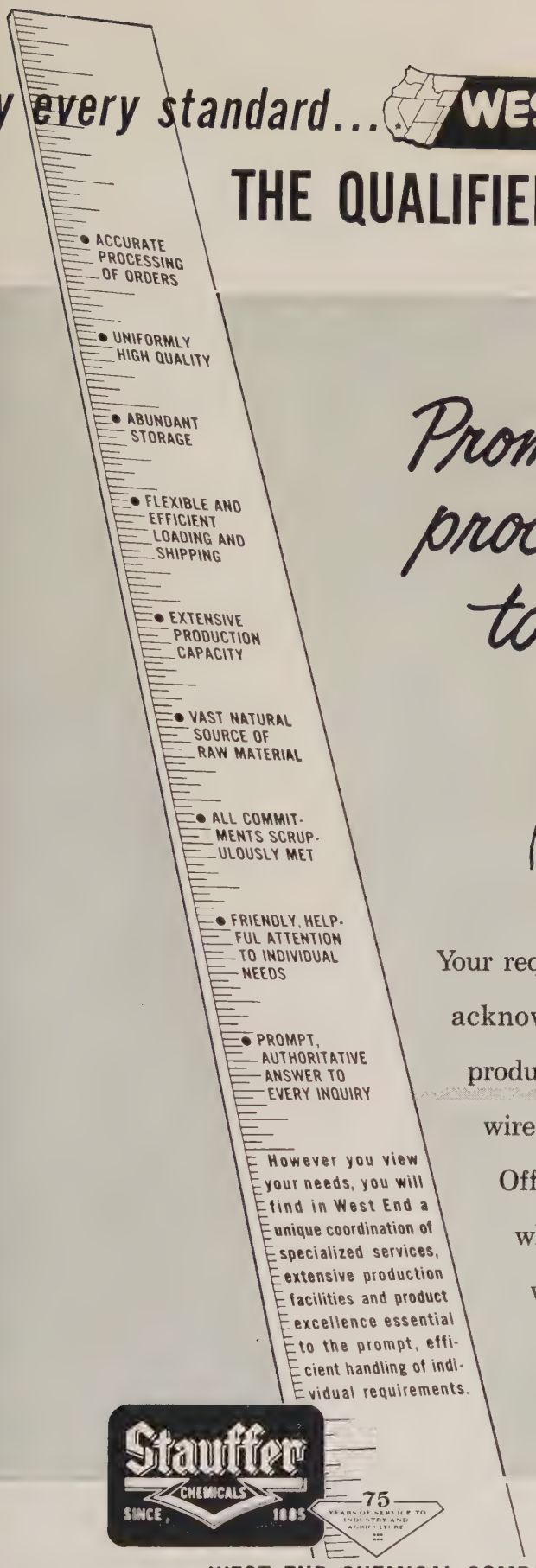
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permanganate number (a measure of lignin content), knotwood is more difficult to pulp and gives pulp of lower yield than normal wood. Knotwood gives sulfate pulp with lower bursting strength, but with higher tearing strength and bulk than normal wood.

12. Reaction Wood

Reaction wood as a type tends to be undesirable for papermaking. However, because it is usually a small portion of the total raw material it can be tolerated by any of the processes. Commercial pulp quality could be affected significantly only if the wood supply consisted largely of tops or branches or of bolts from an undesirable site or genetic strain.

The compression wood of conifers is more dense than normal wood but also always contains much more lignin. Pulp yield on a weight basis is considerably lower, but on a volume basis is roughly equal to normal wood, at a given bleachability. Cooking chemical usage has to be increased and bleaching time should be increased because the residual lignin is more deeply seated than in normal wood. All pulps from compression wood are considerably weaker than normal pulps; those made by alkaline processes are tolerably strong, those from acid processes are probably useless except for "filler" pulp. Properly delignified compression wood should produce a good dissolving pulp. Compression wood produces a much inferior groundwood pulp.

The tension wood of hardwoods is also more dense than normal but possesses a high cellulose and low lignin and pentosan content. The wood therefore delignifies and bleaches more easily. Pulp yields reflect this situation: yields are very high on a weight basis and exceptionally high on a volume basis. The low pentosan content and very high cellulose content may make tension wood desirable for dissolving pulp but, on the other hand, result in chemical papermaking pulps with exceptionally low strength, for reasons not well understood.

In strong contrast to compression wood, tension wood produces a superior groundwood pulp.

13. Properties and Proportions of Nonfiber Wood Elements

Vessel members, longitudinal parenchyma, ray parenchyma, and ray tracheids are generally thought of as having mainly a negative influence on paper properties. Epithelial cells are often ignored because it is assumed that they are destroyed during pulping.

Large vessel members are undesirable in printing grades of paper because they tend to be pulled out of the surface during printing, with resultant poor ink impression. In contrast, the other nonfiber wood elements cause more difficulty in the paper mill itself, particularly with regard to slowing the drainage of the stock.

Ray parenchyma and epithelial cells not destroyed in pulping often contain a very large amount of resin, which leads to pitch troubles in mill operation, with associated high incidence of paper defects. Also, the undesirable phenomenon of self-sizing of paper (spontaneous development of resistance to water penetration) often occurs if these resin-bearing cells find their way into the finished product. It is usually found, however, that alkaline pulping removes the resins involved.

Ray and longitudinal parenchyma cells constitute a major proportion of the fines fraction of paper; other characteristic components of the fines fraction in the case of hardwood pulps include fragments of these cells, of fibers, and of vessel members.

In conifers, ray volume rarely exceeds 5%, but in hardwoods the ray volume may be as much as one-quarter or one-third of the total wood volume. Longitudinal parenchyma is absent in most coniferous pulpwoods but in American hardwoods the volume may exceed 15%.

In pulping, the presence of tyloses in the vessels of certain hardwoods is considered undesirable in relation to cooking liquor penetration.

C. ASSOCIATED WOOD PROPERTY AND PULP PROPERTY CONSIDERATIONS

Important Correlations between Wood Properties

While the properties of interest have been listed and discussed one by one, it will be apparent that a realistic treatment must describe not only the relationships which exist between these wood properties and pulp properties, but also any significant interrelations which have been discovered between one *wood* property and another.

Two such relations are prominent. Thus for slash pine (*Pinus elliottii* var. *elliottii*) it has been established that there is a close inverse relationship between fiber length and micellar angle, both within and between trees, and there are strong indications that this relation may apply to many other species. Also in coniferous species with prominent summerwood, variation in per cent of summerwood appears regularly to be the chief factor controlling wood density.

"Core Wood" vs. "Outer Wood" Properties

It would be difficult also to understand the importance and influence of the thirteen wood properties as reported in section B if one neglected to consider how some of these may vary in the wood in characteristic patterns from the pith outward toward the bark.

Throughout the tree's bole in species which have been studied, there is a rapid change in certain fiber and tracheid characteristics as samples are taken from the pith to the bark. This change is quite rapid for the first several years, then becomes less or ceases altogether, depending on the characteristic concerned. The region of rapid change near the pith is sometimes termed "core wood," and the region further out is called "outer wood." It must be emphasized that these are not discrete zones, but grade into each other so that no sharp delineation is possible. In some species, such as loblolly pine, the wood has a different appearance near the pith than further out, nearer the bark, and it is possible to make a very crude visual separation.

Wood produced near the pith (core wood) has the following characteristics, compared to outer wood from the same tree:

1. *Fiber Length.* Shorter fibers, often $^1/_2$ or $^1/_3$ as long as those in the outer wood, are characteristic. The change in length is abrupt near the pith but in most species studied there appears to be a continued change for a number of years.

2. *Density.* In most coniferous species density is

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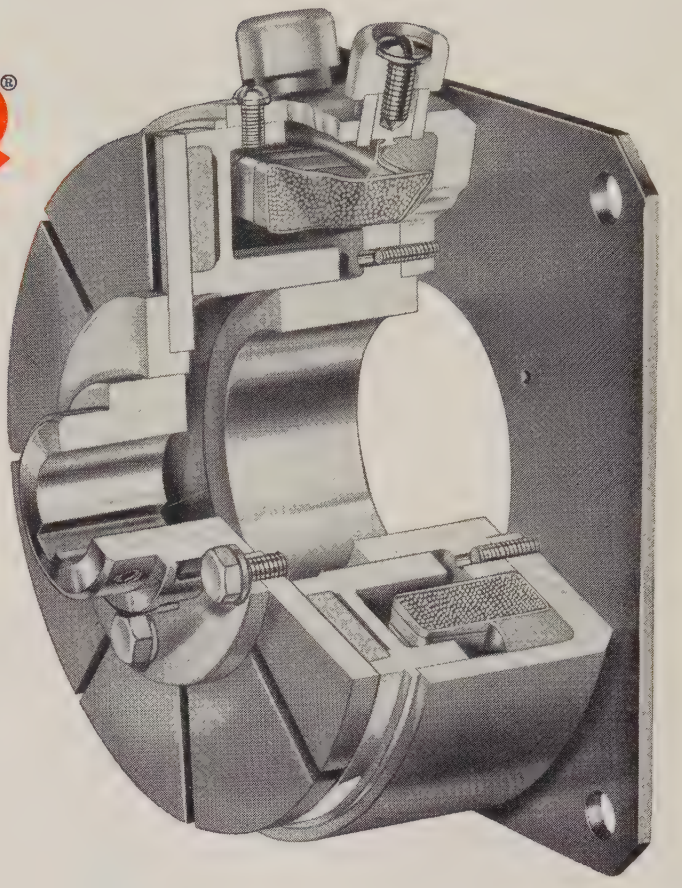

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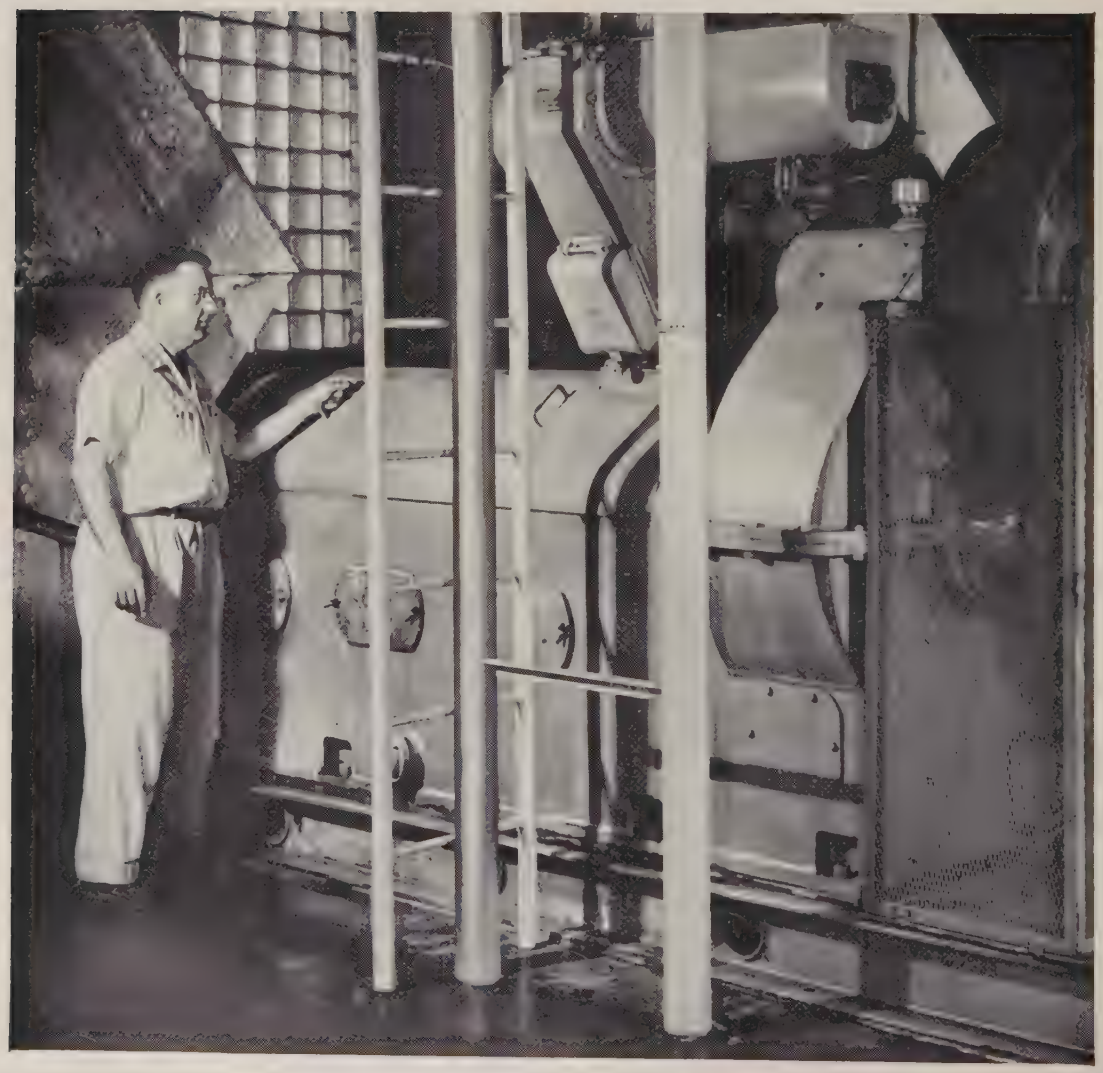

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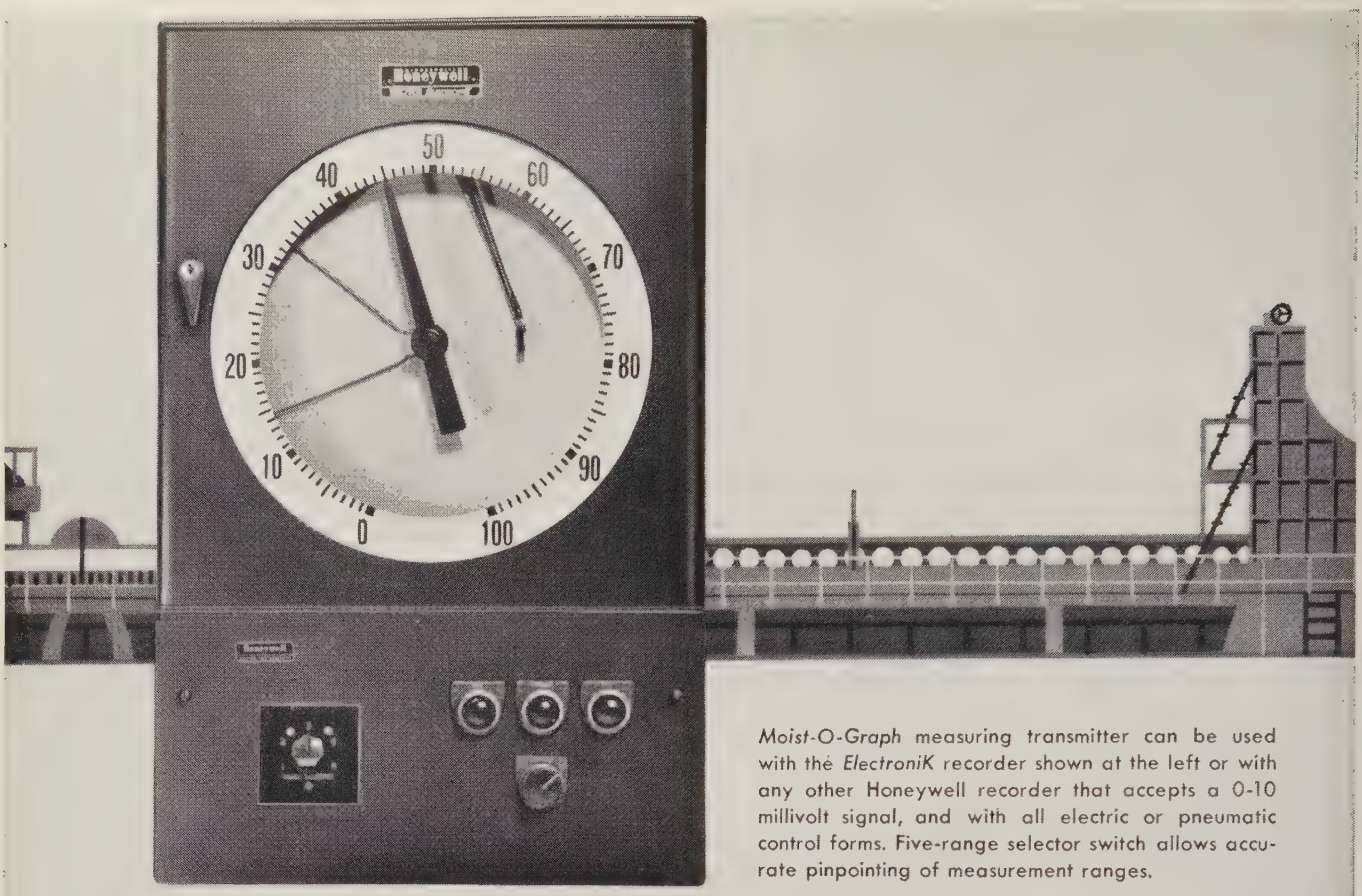

Moist-O-Graph measuring transmitter can be used with the *ElectroniK* recorder shown at the left or with any other Honeywell recorder that accepts a 0-10 millivolt signal, and with all electric or pneumatic control forms. Five-range selector switch allows accurate pinpointing of measurement ranges.

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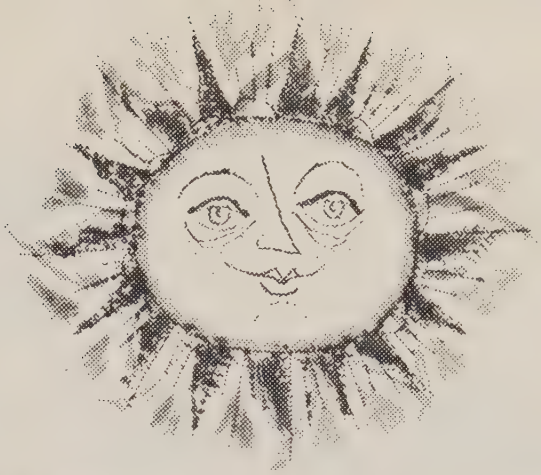

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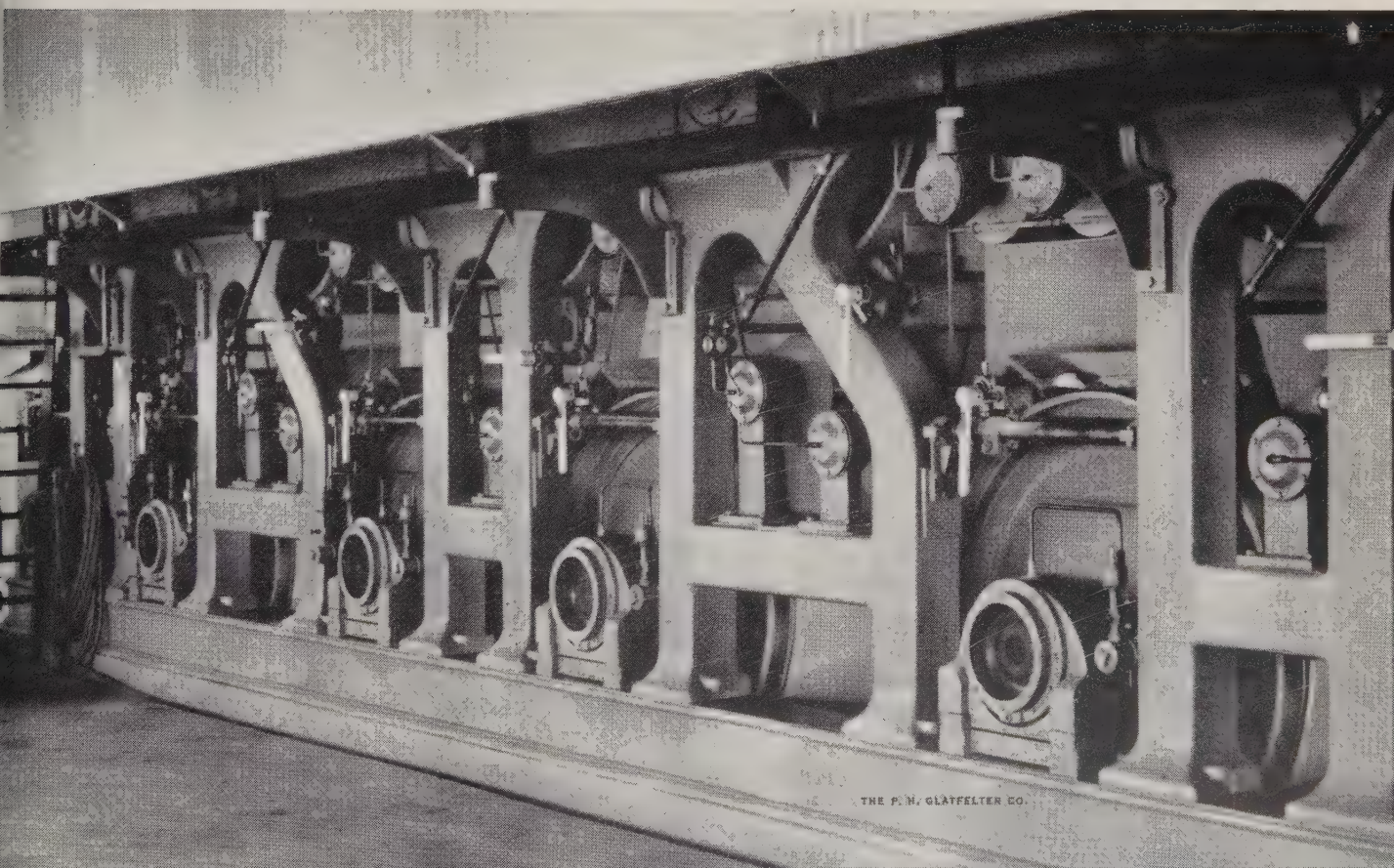
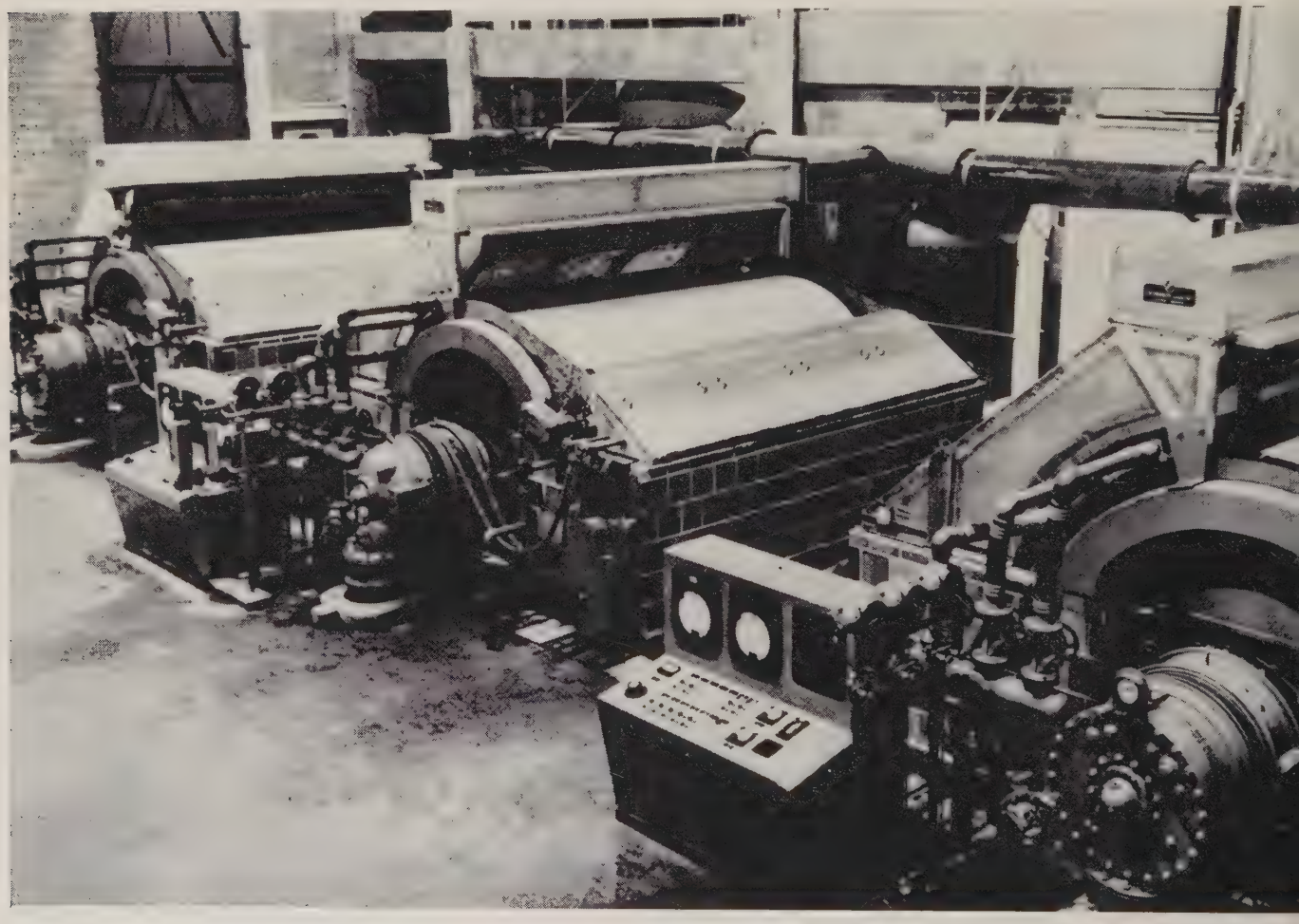


Complete Dorr-Oliver Continuous BLEACHING SYSTEM

installed at
St. Lawrence Corporation, Limited



WHEN the old-established St. Lawrence Corporation, Limited decided to add a bleach plant to its newsprint and kraft liner board mill at Red Rock, Ontario, extensive investigation resulted in the choice of a Dorr-Oliver Continuous 3-Stage Bleaching System. Advantage was taken of the local engineering and manufacturing services of Dorr-Oliver's associated Canadian company, Dorr-Oliver-Long Limited, which supplied all equipment.

The washing system comprises three 8′ dia. x 12′ face washers, designed for an ultimate capacity of 200 tons per day. The first is a rubber covered chlorination washer, which includes a press roll. The second stage is the caustic extraction washer, constructed of stainless steel for possible future chlorine dioxide service. The third and final stage is a rubber covered hypochlorite washer. All washers have double roll dischargers and are in tile vats with fibreglass hoods.

For complete coordination of all phases of the bleaching operation, choice was also made of a Dorr-Oliver rubber lined chlorine mixer, two heater mixers and circulators for the caustic and hypo towers.

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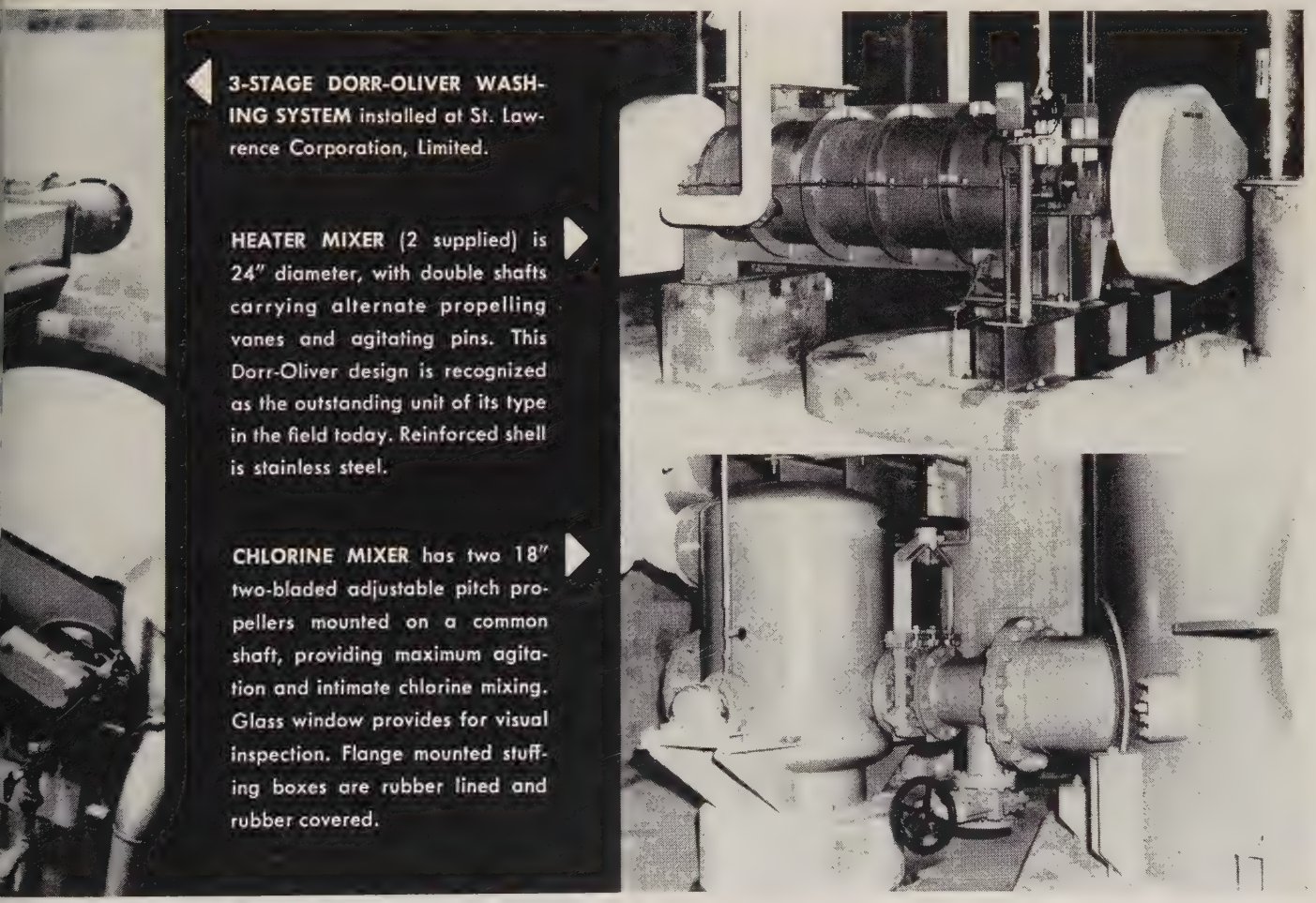

3-STAGE DORR-OLIVER WASHING SYSTEM installed at St. Lawrence Corporation, Limited.

HEATER MIXER (2 supplied) is 24″ diameter, with double shafts carrying alternate propelling vanes and agitating pins. This Dorr-Oliver design is recognized as the outstanding unit of its type in the field today. Reinforced shell is stainless steel.

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very low near the pith, increases rapidly for a period of 10 to 15 years and then tends to level off. Hardwoods show several patterns, but the diffuse porous woods tend to have lowest density near the pith. Species such as sweet gum tend to increase in density for 10 to 20 years, then drop in density. The evidence for density variation in ring porous hardwoods is of several kinds, some reports even showing highest density near the pith.

3. *Cellulose Yields.* Studies to date on pine show a rapid increase in cellulose yields for about the first 10 years, followed by a leveling off. Early studies show core wood yields of cellulose to be about 7% less (on dry weight basis) than outer wood of the same tree.

4. *Fibril Angle.* Wood formed near the pith has a very large fibril angle, and the angle decreases in the bark direction.

5. *Chemical Constituents.* Differences have been shown in pentosans, hemicelluloses, lignin, and other substances, but do not lend themselves to clear interpretation at this time.

6. *Compression Wood.* Studies in pine show core wood to have about 50% compression wood. Cause and effect are not clear. It is possible that some of the core wood characteristics are due to the large amount of compression wood. Core and compression wood have many characteristics in common, but a notable exception is cell wall thickness.

While most information so far has come from conifers, in at least certain hardwood species—including some specifically mentioned above—there is evidence that several wood properties follow a similar pattern of pith-to-bark variation. Too few hardwood investigations, however, have been made to permit much well-based generalization.

The characteristics listed here demonstrate how important are the wood property differences between core wood and outer wood. Core wood is of special importance in young trees and top wood, and a high proportion of either can materially affect pulp and paper properties.

It has been suggested recently that variation in certain of the core wood properties may be more closely associated with distance from the pith than with age. Such a relation would favor rapid early growth in diameter. Age, in any case, has such an inescapable association with core wood properties that age differences should always be taken into account in wood property comparisons involving different individual trees or different populations.

Some Comments on the Complexity of Wood Property-Pulp Property Relationships Discussed in Section B

The statements for the several wood properties described in Section B sometimes reveal that a single wood property has strong correlations with more than one pulp property, and that these correlations may be positive with one property and negative with another.

Thus, for instance, fiber wall thickness is related directly to volume basis pulp yield and fiber strength, and inversely to fiber flexibility. Also, fiber length is related directly to tearing strength and inversely to formation (relative homogeneity of the paper fiber network). In both of these illustrations an increase up to a certain point may be desirable with respect to the directly related pulp properties, but beyond a certain level further increase will be undesirable because the negative correlation—which happens to be unfavorable—with another important pulp property is then being too prominently expressed. In both instances, however, it often appears possible to enhance the level of the wood property substantially before untoward effects are considerable enough to be taken into account.

Another feature of complexity in wood property-pulp property interrelationships concerns the effects of fiber dimensions. It is pointed out that the length, width, and wall thickness of fibers are interrelated in their effects in papermaking in a complex and little understood way. It may be added here that in hardwoods the ratio, $2t/w$, where t is wall thickness and w is lumen width, has been found a useful expression in relating fiber dimensions to their conformability in papermaking.

D. HOW MUCH IMPROVEMENT WOULD BE SIGNIFICANT?

While there has been no systematic attempt in the individual wood property statements to specify how much improvement in the property might be considered significant, perhaps it is not too early to venture some statements in this regard, not as prescriptions to be applied in a tree improvement program without due attention to all relevant considerations, but as general observations.

Thus, in many southern pine kraft operations, a 5% average increase in wood density, through selection for this property, would be expected to have a distinctly more favorable economic impact than selection applied to produce to a 5% average increase in fiber length. Also, for most full chemical pulping operations, especially if they are followed by bleaching, an average reduction in lignin content of as much as 2 to 3% would appear to be quite attractive, other things being equal. A comparable increase in alpha-cellulose content would probably usually be worthwhile in chemical pulping because of its favorable effect upon pulp yield.

There is strong agreement in the industry that not only good properties, but, in many instances, uniform properties should be sought. Perhaps it may be useful briefly to explain why this is an important objective and how it can be approached by both the silviculturist and the geneticist. One of the chief barriers to efficiency in the industry is the heterogeneity of (1) its product composition and (2) further back, of its raw material composition. Thus, the fibers which are matted together in a sheet of any specified grade of paper are far from uniform in many of their properties. Individually, each of the constituent fibers must tend either to contribute to or detract from the overall quality of the sheet for a specific use. The wood raw material, moreover, as it is received from nature, before processing, is likewise a complex of materials, arrangements, and properties. Some of these features exhibit wide variation within the tree, and some show important differences when individual trees are compared.

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depends heavily upon uniform processing. But progress is made toward both objectives if the day-to-day supply of wood to the mill can be managed so as to reduce important variations in average wood properties.

This reduction can be accomplished in three ways. One method which is now receiving attention is to develop and plant trees which are genetically similar as regards the significant wood properties. This approach, within certain bounds, seems quite promising, though the field has only just been entered. A second approach, which has some good, though not comprehensive, experimental evidence to support it, is to effect a biological control which will reduce important wood property differences between different regions within the same tree. This sort of manipulation is within the sphere of the silviculturist and, apparently to a lesser degree, of the forest geneticist. Study of the potential of both methods is being incorporated in long range programs aimed at wood quality improvement.

A third method, which is relatively simple, currently available, and could be adopted by many mills, is to mix individuals together to obtain the average properties or property combinations sought.

From the processing standpoint, a combination of the first two methods is the most desirable, but for application in the present and in the immediate future, it is the third approach which commends itself. A forest manager who is aware of the average wood characteristics in each of the various stands under his control may today often be able to plan his harvesting operations so as to furnish the pulp mill with a reasonably uniform average wood raw material from relatively large areas, for extended periods of time.

There is a strong trend in pulping today toward milder processes which retain in the product more of the original wood constituents and more of their original properties. This trend tends to enhance the role of the forest biologist in seeking effective means to exert at least partial control over these properties in future forests.

Even though it is not possible today to see far enough ahead to predict just what levels and combinations of wood properties will be called for in decades to come, the individual wood property summaries given in this report can serve as useful guideposts along the way for both the geneticist and the silviculturist. In the meantime, the pulp and paper scientist must continue his efforts to assess the significance of wood properties for various paper products and according to various pulping methods. And the forest biologists must also press their broad front quest for more effective control of the significant wood properties as they develop in the growing tree.

Lest it might not have been sufficiently emphasized earlier, let us repeat here that a wood property which is certified by the pulp and paper scientist has only tentative status for the forest manager until the forest biologist has demonstrated by experiment that he has a sufficient practical control over the environmental and/or genetic factors which cause the property to vary.

E. THE REPORT IN PERSPECTIVE

The report reveals or implies many gaps in the understanding

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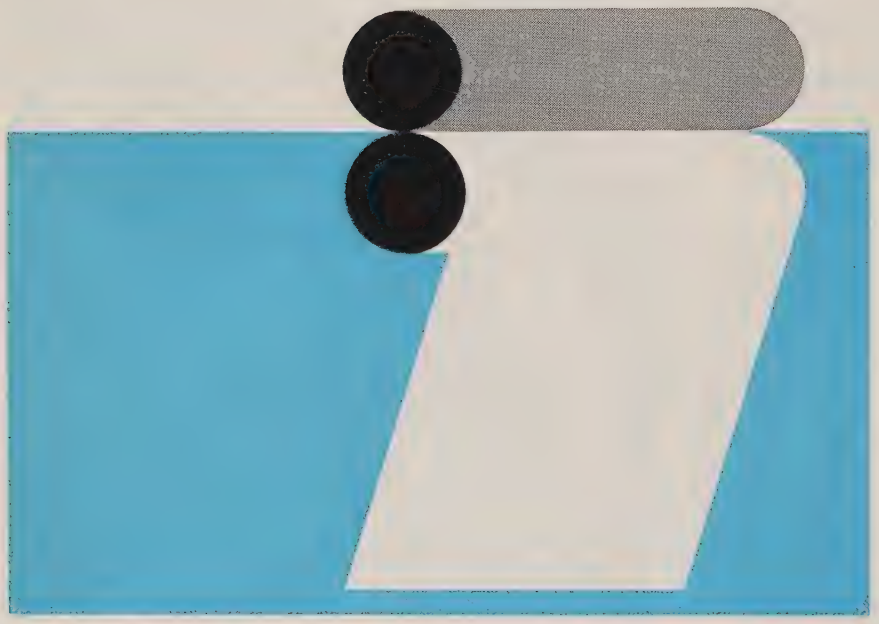

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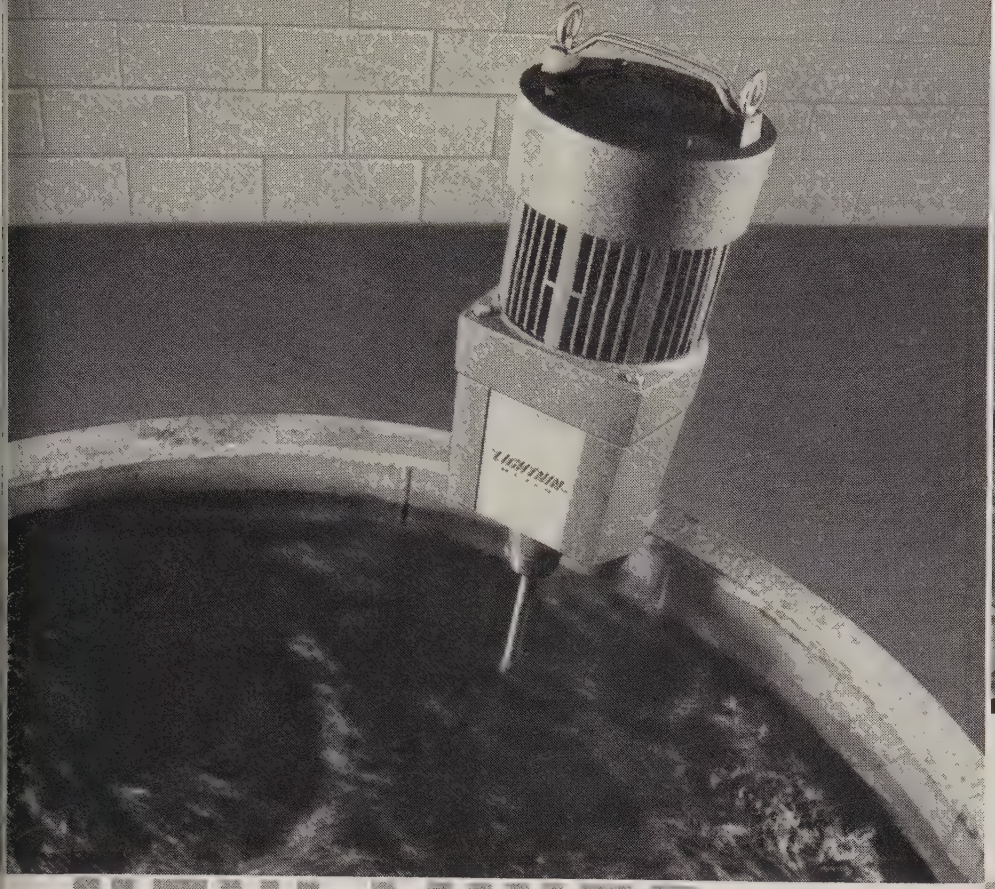

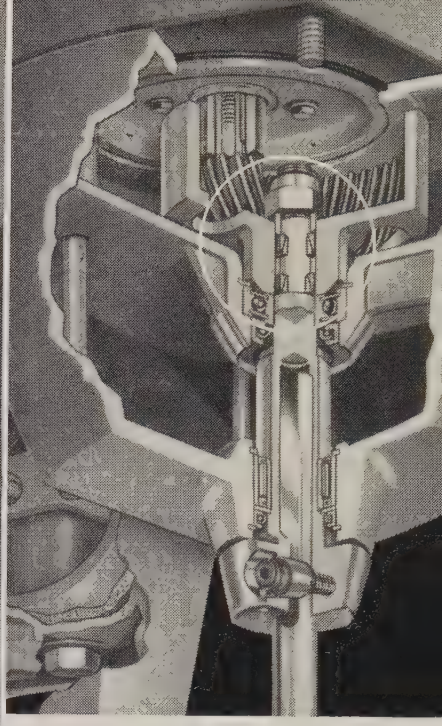

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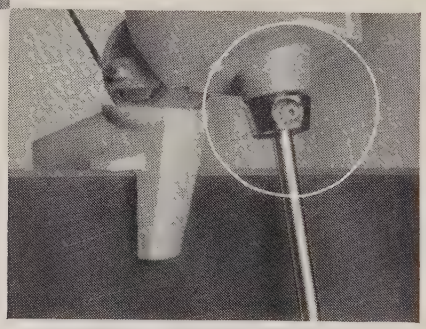
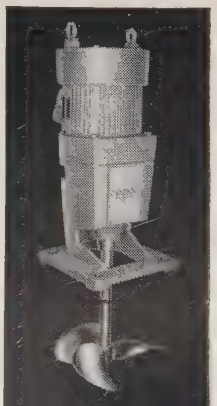


SAVE COST of a corrosion-resistant alloy with this shaft chuck. It's way up out of the tank—always above liquid level. It's simple, quick-acting. Tighten one screw, and shaft is locked—can't come loose unless you want it to.

NO MYSTERY about the right mixer angle for best mixing. Vertical and horizontal indexing makes it a snap to describe the right setting so everybody understands.

IN FIXED MOUNTINGS, TOO. Get the same all-new advantages in permanent-mounting LIGHTNIN Mixers for open and closed tanks. A complete line, sizes from ¼ to 3 hp. For details on these, send for Bulletin B-521.



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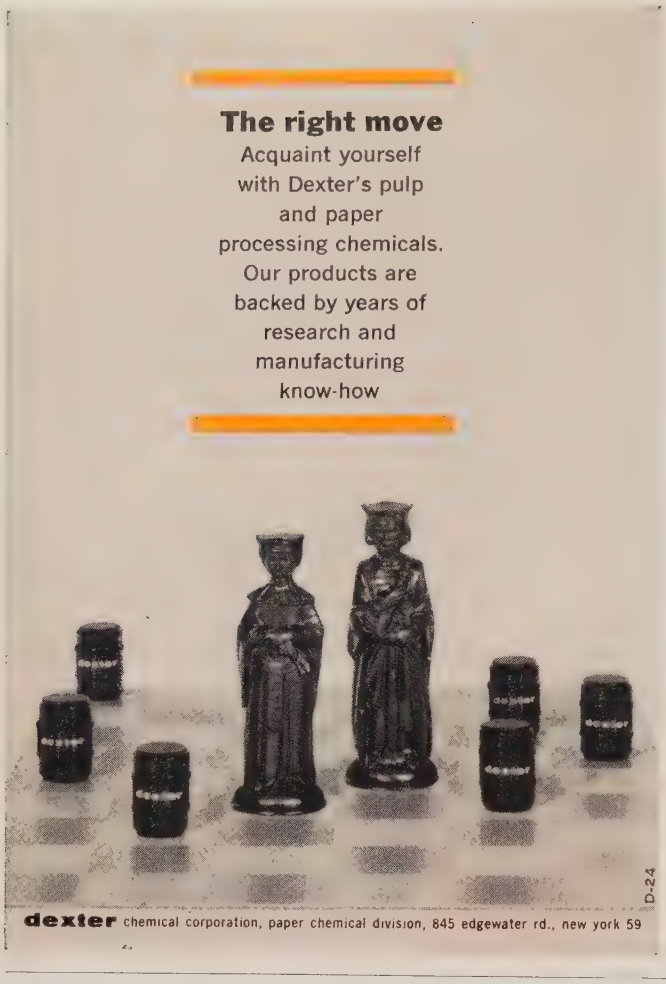

of how the complex operations of pulping and papermaking are influenced by morphological, physical, chemical, and physicochemical variations in wood properties. While deeper research penetration into these areas is vital to the wood property orientation of the forest biologist, it was recognized much earlier to be essential to improvements which are within the sphere of the pulp and paper engineer. As new knowledge becomes available, we may continue to expect the engineers of the pulp and paper industry to translate it into technological improvements which will often overcome more efficiently than could the forest biologist, some of the problems which might be considered to be open to attack by either approach.

Also, it should be noted that the relationships between different wood properties described in this report are sometimes based upon studies of very limited scope, not always of what today might be considered adequate design, and often involving only one or a few species. Investigation of additional species may show new relations. Recent study of *Araucaria* and *Agathis* species, for instance, has shown that in these coniferous species, in which summerwood is inconspicuous, there is virtually no density variation from pith to bark.

The present effort is but a first attempt to summarize available information in a wide field of cooperative concern. Our views in some fundamental areas in pulping and papermaking and in wood research are currently undergoing vigorous experimental attack. New information will probably require revision of this report before long. The committee particularly welcomes criticisms and suggestions.

In this first edition, an effort has been made to include available information on both the coniferous and the hardwood species which are important as sources of pulp. The southern pines, however, have so far attracted the strongest focus in wood property improvement in this country, and the report therefore somewhat reflects this circumstance.

F. PARTICIPANTS

More than 20 Forest Biology Committee members gave substantial aid in compiling this report. It was initiated under the Subcommittee No. 2 chairmanship of Peter T. Lannan, Jr. · Current and former subcommittee members who participated actively are named below.

Pulping and Papermaking; L. A. Hiett, M. G. Lyon, D. J. MacLaurin, M. N. May, B. K. Mayer, Secretary, F. E. Pollock, J. R. Salvesen, R. J. Seidl, R. F. Sultze, Jr., and E. F. Thode.

Forest Biology; R. M. Echols, vice-chairman, P. N. Joranson, chairman, H. L. Mitchell, M. Y. Pillow, T. O. Perry, F. F. Wangaard, and B. J. Zobel.

Woodlands Operations and Research; C. H. Driver and P. T. Lannan, Jr.

Others who contributed importantly were L. Besley, K. W. Dorman, I. H. Isenberg, G. R. Sears, J. E. Stone, and J. A. Van den Akker.

Participants represented a number of pulp and paper companies, the government services, and educational and research institutions.

This report includes, in addition to information from published research, also some derived from unpublished research. Where judgments based upon personal experience or unpublished research have been expressed, these have been worded as faithfully as possible and regularly submitted for critical review in an effort to present authoritative current opinion.

A bibliography of the world literature dealing with environmental and genetic effects on properties which are important in pulpwood is being prepared by the Subcommittee No. 1, on Bibliography, of the TAPPI Forest Biology Committee, under the leadership of Philip R. Larson, chairman. It will take the form of a selective abstract bibliography, and is soon to be published.

45th

Annual Meeting

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Hotel Commodore

New York, N. Y.

Feb. 19–23, 1961

Illustration courtesy American Stores Co.

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for converting
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From chlorine and caustic for bleaching pulp—to polyethylene resins for coating paper and board—U.S.I. is a dependable source of chemical products for the paper industry.

With two chlorine and caustic plants at Huntsville, Alabama—conveniently located in relation to a large number of pulp and paper mills—U.S.I. can offer rapid delivery and prompt technical assistance on these products. Liquid chlorine is available in tankcars. Commercial grade 50% caustic soda is shipped in tankcars, tank trucks, barges.

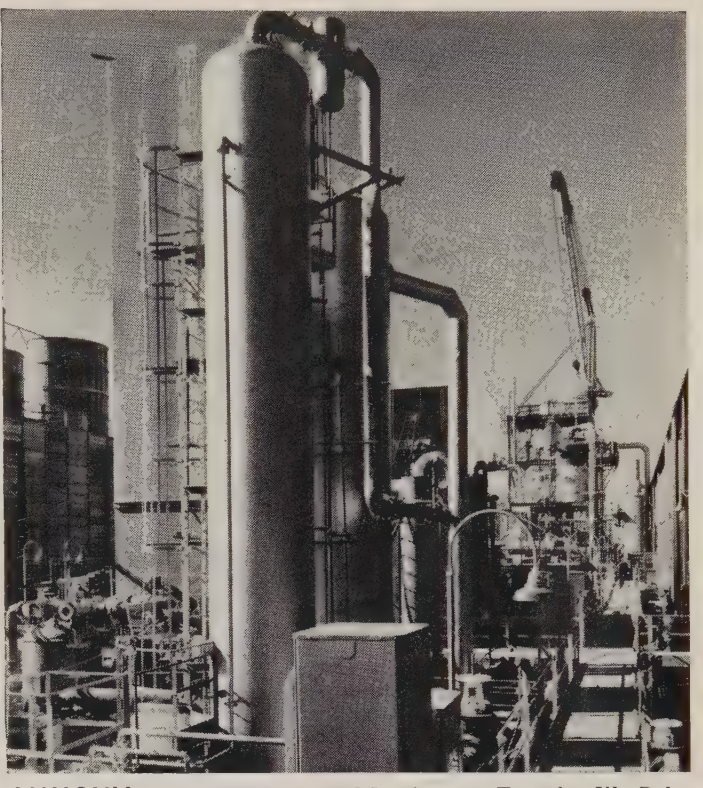
Two other important paper chemicals—sodium peroxide and ammonia—are also available from U.S.I. Sodium peroxide is produced at Ashtabula, Ohio; ammonia at Tuscola, Illinois.

With U.S.I.'s latest polyethylene resin plant expansion at Houston, Texas—and facilities at Tuscola, Illinois—the company's total polyethylene capacity will soon reach 300 million pounds per year. This will make U.S.I. the world's second largest producer.

As part of the company's program to assist polyethylene customers, U.S.I. has come up with significant developments in resins for the paper industry. For example, PETROTHENE® 205-15—one of four new U.S.I. resins for paper coating—exhibits greater greaseproofness at any given coating weight than other resins of similar melt index and density. All four resins are tailored for high adhesion, and reduced neck-in, smoking and polymer build-up at the die.

U.S.I. has also pioneered the new technique for producing crystal-clear cast polyethylene film, and has just released new resins for this purpose. More and more converters are packaging with polyethylene now that the clarity problem has been solved, because of the enhanced shelf life which this film gives to paper products.

U.S.I. has a pulp-to-package interest in the paper industry's growth. To take advantage of our research and development work, large capacity, prompt technical service, write or call your nearest U.S.I. sales office, or company headquarters in New York.



AMMONIA is made at this U.S.I. plant at Tuscola, Ill. Polyethylene resins are also produced at Tuscola by U.S.I.

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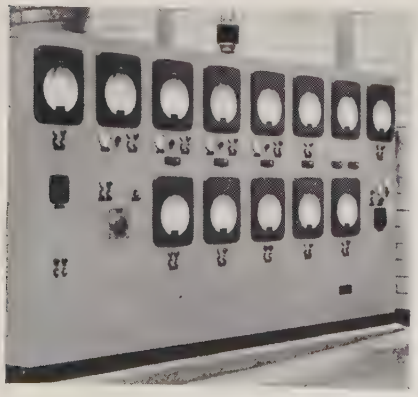
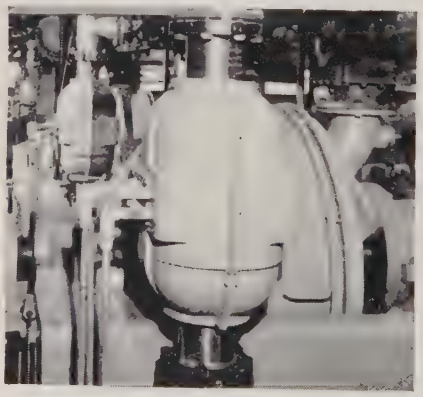
Pulp stocks, chemicals
no liquid is too tough for the

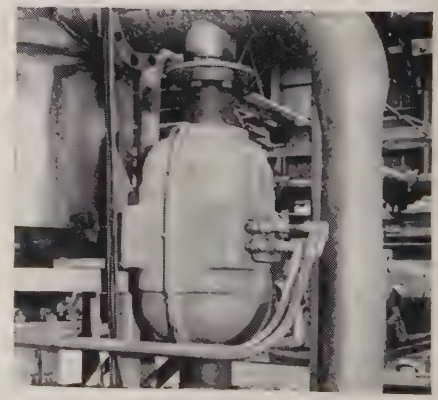
Crown-Zellerbach Antioch, Calif. uses Foxboro Magnetic Meters for blending fir and hemlock stocks. Rugged meters are installed outdoors — need no protective housing.



Foxboro Dynalog recorders give operators continuous chart records of the Magnetic Meters linear output. Like the flow meter, Dynalog recorders seldom require maintenance.



St. Regis Paper Company, Jacksonville, Florida. St. Regis uses 5 Foxboro Magnetic Flow Meters in its stock refining system. Meters are 6″ in diameter. System was installed in 1956.



Riegel Paper Corporation, Acme, North Carolina. Riegel has several Magnetic Meters in its mill. The 8″ meter shown above measures broke flow in their pulp stock blending control system.

ıdditives, dyes...
Foxboro Magnetic Flow Meter

hundreds of successful installations reported by America's leading mills

Introduced six years ago, the Foxboro Magnetic Flow Meter has proved its superiority for measuring the toughest pulp and paper mill liquids. Pulp stocks, mud slurries, starch, liquors all flow right through the meter without plugging up.

That's because the Magnetic Meter has no flow restrictions of any type. No taps to get plugged or frozen, no seals or purges, no moving parts of any kind. Measurement is made by electrodes flush-mounted in corrosion-proof meter wall — then transmitted by electric cable to a Foxboro Dynalog* electronic recorder. System accuracy is ±1%.

Foxboro Magnetic Flow Meters have solved some of the paper industry's toughest measurement problems. Ask your Foxboro field engineer to show how it can help with yours. Or write for Bulletin 20-14. The Foxboro Company, 7811 Neponset Avenue, Foxboro, Mass.

Reg. U.S. Pat. Off.

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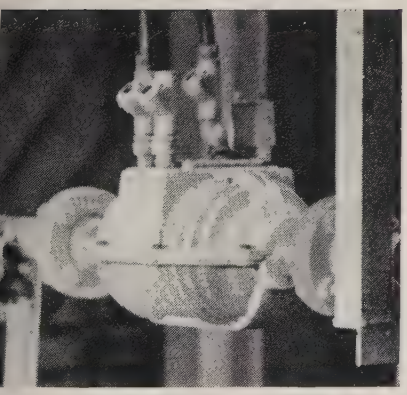
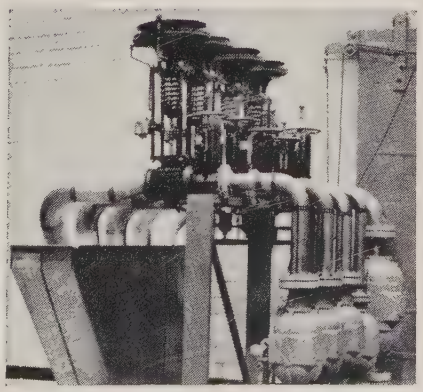
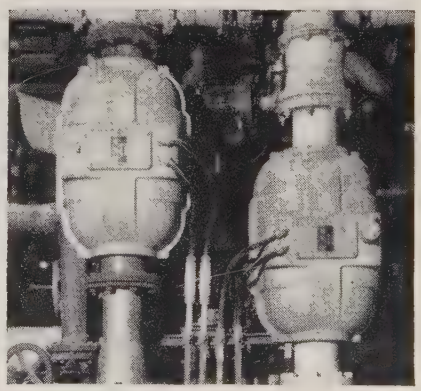


Gulf States Paper Corporation, Demopolis, Ala. Gulf States uses this 2" Magnetic Meter to measure chlorine dioxide flow. This highly corrosive chemical has no effect whatever on the Magnetic Meter.



International Paper Company, Corinth, New York. At International Paper, Foxboro Magnetic Meters allow one operator at a central panel to blend 5 pulp stocks — as well as additives and dyes — accurately and continuously.



Scott Paper Company, Chester, Pa. Scott has a total of 9 Foxboro Magnetic Flow Meters. The first installed on a bleach line over 6 years ago, has required maintenance only once — a new vacuum tube for its Dynalog recorder.

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It's easier to *throw* dirt out than it is to *wash* it out. And it's easier to maintain the right whiteness, brightness and opacity of lightweight disposable paper products—towels, facial tissues, napkins and many others—if you use the *right* kind of TITANOX white titanium dioxide pigment.

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However, TITANOX-RA-50, the truly multi-purpose rutile TiO_2, or TITANOX-A, anatase TiO_2, may be better suited to your particular operation. One sure way to find out is to get in touch with our Technical Service Department. They'll be glad to discuss the type of TITANOX that will give you the best value for your pigmentation dollar. Titanium Pigment Corp., 111 Broadway, New York 6, N. Y.; offices and warehouses in principal cities. In Canada: Canadian Titanium Pigments, Ltd., Montreal.

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contributes to improved printability and luster; reduces dusting.

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facilitates applications of paper coating and improves quality of the finish.

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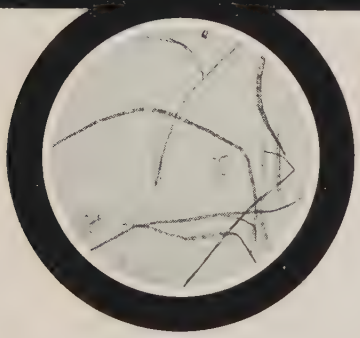
This new integrated pulp and paper mill produces 100 tons per day of high grade bleached and unbleached papers from sugar cane bagasse fiber. Our Organization supplied this project with technical assistance and the major production equipment including a Horkel System for depithing and cleaning the raw bagasse, a Pandia Continuous Digester and the Black-Clawson fourdrinier paper machine shown here.

Completely depithed bagasse fibers

NEW MILLS MAKING PAPER FROM BAGASSE AND STRAW



Wheat straw fibers

EMPAQUES DE CARTON TITAN S.A., MONTERREY, MEXICO

Under a package contract, we supplied principal equipment and start-up assistance for the recent expansion of this mill to produce 60 metric tons per day of unbleached wheat straw pulp for corrugating medium. Straw processing and pulping in a Pandia Continuous Digester is accomplished in this compact, semi-enclosed installation.

These Latin American projects are but two of the 25 pulp and paper mills throughout the world for which the Parsons & Whittemore-Lyddon Organization has provided full or partial planning, technical, economic, and construction services. Twelve different papermaking fibers are utilized among these projects. We even supervise start-up and train local operating personnel, and can arrange for sale of the output on world markets. For literature and full information on how our services can benefit your mill projects, write our nearest office.

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World leaders in the development of pulp and paper mills for the use of local fibers

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Paper board for milk cartons, ice cream containers and other food packaging can now be dyed with National® Certified Colors . . . **at no increase in cost as compared with conventional dyes!**

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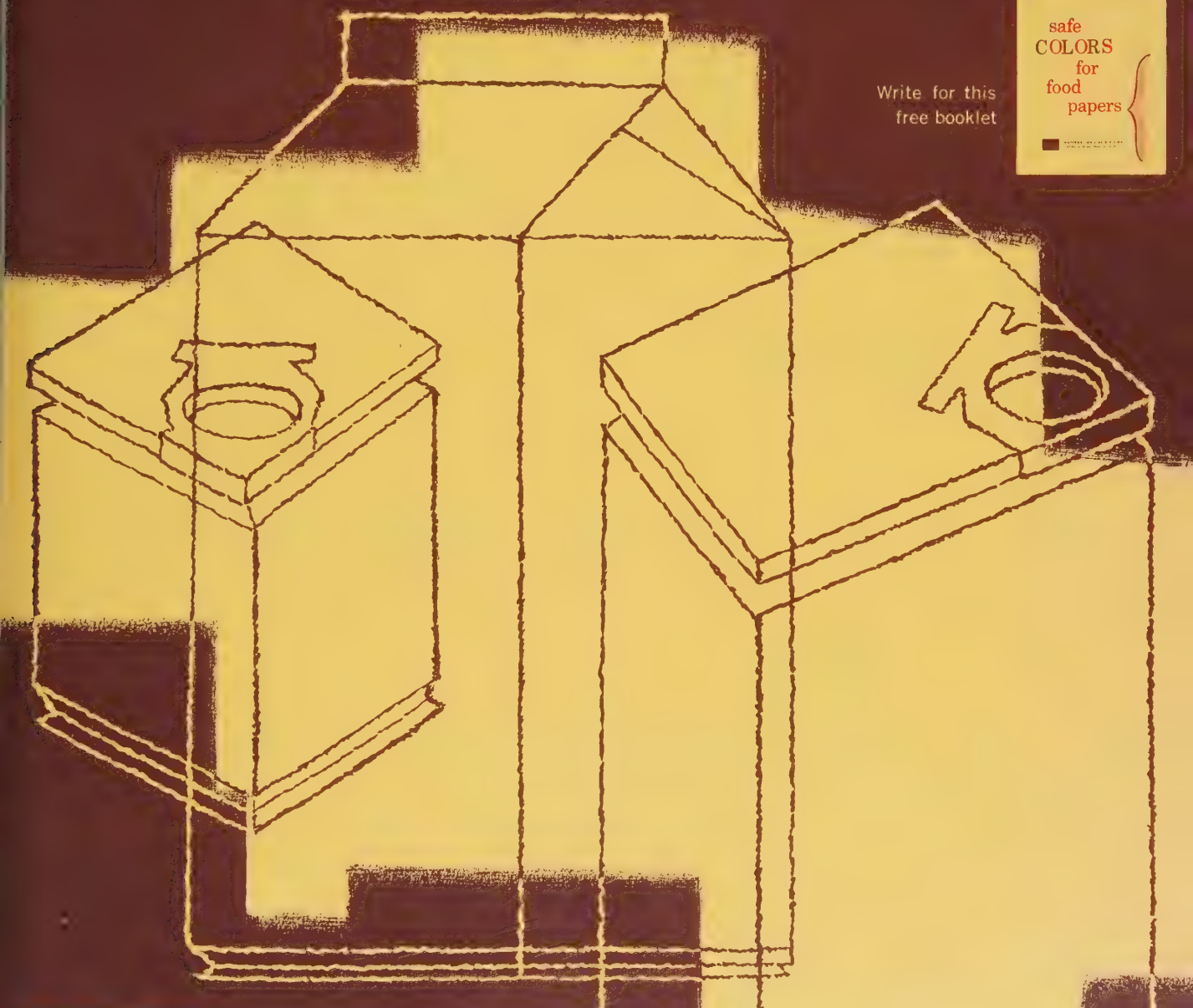
Working with conventional dyes as well as certified colors, we are engaged in intensive research, independently and in cooperation with the chemical and paper industries, to solve the many problems that still exist in coloring food papers under the Food Additives Amendment.

We will be pleased to assist you any way we can.

Write for this free booklet

safe COLORS for food papers



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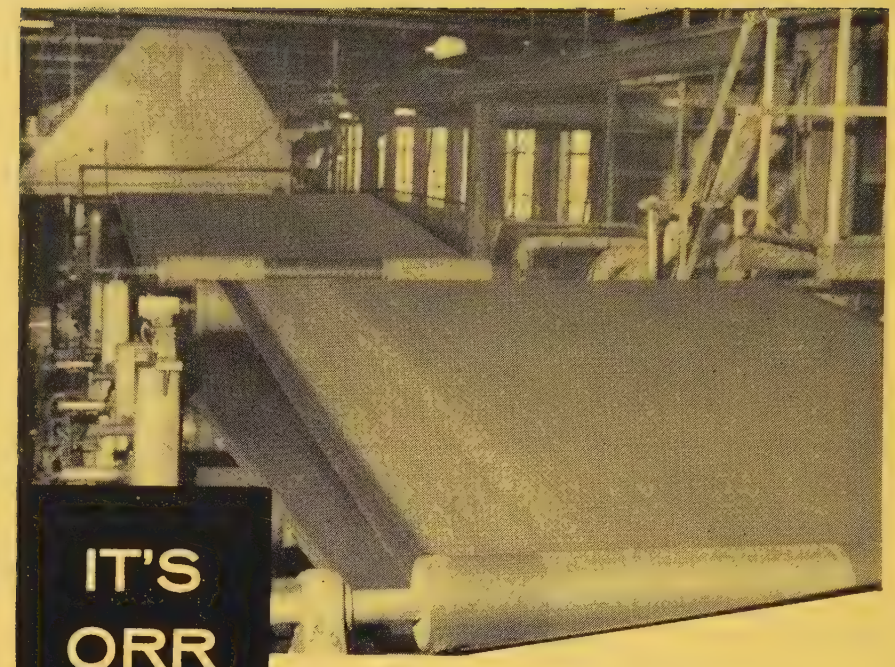

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The user-benefits this Orr felt is providing at The Mead Corporation's board mill in Cincinnati are typical of Orr felts everywhere.

Custom engineered to your exact specifications, these quality felts assure good finish and long life on the machine, greatly reducing downtime and maintenance costs. That's why so many papermakers specify Orr.

For complete information, check with your Orr representative or write us direct.

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Bags, cartons, cases, cups, films, foils, labels, laminates . . . whatever your bonding requirements, there is a Borden adhesive designed to provide operating advantages. Each grade has been perfected in Borden's research and development laboratories, and proven by performance in production applications. Consider Borden when looking for the *right* packaging adhesives . . . Borden know-how is available to help you do a better job. Write for a copy of Borden's Packaging Adhesive Index: The Borden Chemical Company, Resins and Chemicals Dept. T-110, 350 Madison Avenue, New York 17, N.Y.

THE BORDEN CHEMICAL COMPANY ©TBC

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Suggestions on the Care of Filled Calender Rolls

Storage Problems And Running-In of Green Rolls . . . Repairs — Embossing Rolls

When a roll is received it has been ground ready for use and should be run-in as soon as possible, because if stored too long its shape will alter.

STORAGE OF CALENDER ROLLS

Always support a roll by the journals or the heads; never rest it on its face; for it will not only rot if the area is damp but the filling will expand and put undue pressure on the heads. Also, where the face contacts the floor a flat line develops, often not noted until the roll is required. Long, heavy rolls, supported by the journals or heads, may in time run out at the center due to the weight of the filling on the shaft. To avoid this, rotate the roll 180° weekly.

If a roll sags from storage, put it into the calender and run at no pressure until it gets back into line. Don't try to remove this run-out by turning, as the run-out will appear again later.

RUNNING-IN CALENDER ROLLS

A green roll deteriorates rapidly unless it has a good crust. While all "Holyoke" Rolls are ground before shipment, this does not produce the crusted surface needed for satisfactory service and long life. This is achieved by running the stack, as described below, when a green roll is first installed.

The rolls should be washed down lightly from time to time with a 3% soap and warm water using a pure soap such as Ivory. Do not use much water but wash down lightly and frequently. Use light pressure. The washing of the rolls will assist in getting the fibre rolls to conform with the chilled iron rolls. After washing down, the rolls should be run dry to allow them to crust over. Pressure should be applied gradually during the period over which the crust is developed and heat added to the chilled iron rolls if possible but not in excess of 140° F. Continue with this procedure until rolls have developed a high finish and are thoroughly dry.

REPAIRING CALENDER ROLLS

In some cases where rolls have broken out it is possible to replace damaged filling. The rolls must be returned to the manufacturer for this procedure.

GENERAL CARE OF CALENDER ROLLS

Narrow webs damage rolls if run any great length of time because the fibre roll runs high at the ends of the web and as a result the fibre will burn. The common practice to avoid this difficulty is to shift the narrow web from side to side in the calender. Oil will cause fibre fillings to rot; oil soaked fibre rolls will produce a different finish from oil-free material.

With some fibres, a roll which has marked can be repaired by repeating the procedure for running-in the roll. If this fails, apply wet pulp to the marks leaving it overnight and run them out the next day. If they still persist, turn them out, taking a 1/8" to 1/4" chip so as to get well below the mark. If marks are sanded out the fibre where the mark occurred will come back, producing a high spot and eventually burn or break out. Actually, sanding is not recommended if it is at all possible to get rid of high spots by turning the roll. The only time sanding can be done safely is when it is necessary to relieve high *ends* of a filled roll.

When turning rolls, either a diamond point or carbide tool (type K-8 Kennametal or equivalent) is recommended since they are hard and their edge will not wear unduly while turning the complete face. Type TSC carbide boring tool is very often used; being reground so as to produce a round-nosed tip with a radius of approximately one-half of an inch.

RUNNING-IN EMBOSSING ROLLS

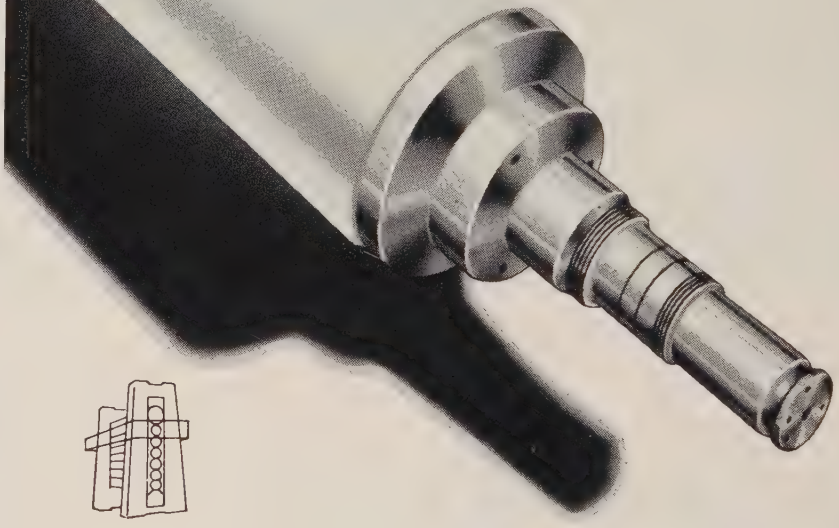
Apply with sponge 3% soap solution on the engraved steel roll allowing the water to become trapped in the nip. As the roll dries out add more water (the roll will dry out rapidly when first run-in due to incomplete roll contact). This process should be repeated until the design is well established in the fibre roll. Pressure should be increased gradually during this run-in process as depth of design increases.

Once full design is achieved run with full pressure without application of water until roll is dried out and crusted over. When crusted over, if design is fully run in, the fibre roll will have a high finish. Where heat is available in the steel roll, the drying and crusting of roll will be accelerated by applying heat. Do not run heat over 140° F.

A good indication of when a roll is fully run-in is that the engraved roll will be clean and shine to full depth and face of the engraving. Do not try to rush the running-in of the fibre roll. The time required to run-in a fibre roll varies considerably from pattern to pattern. The machine should be run at slow speed.

A pamphlet incorporating these suggestions on the handling and care of filled calendar rolls may be obtained from the Holyoke Machine Company, Holyoke, Massachusetts.

"HOLYOKE"
ROLLS
ESTABLISHED
1863



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HOLYOKE 3, MASSACHUSETTS
CALENDER, EMBOSSING, FILLED and METAL ROLLS for INDUSTRY
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WHY CONVERTERS BUY MORE

INTA-ROTO LAMINATORS

THAN ALL OTHERS COMBINED

For Foil, Film, Paper, or Paperboard Lamination

1. Inta-Roto laminators are precision machines, and precision equipment is a must for sustained high speed lamination, for quality lamination, and for laminated materials that can be processed further on other high speed machines.

2. Constant, accurate maintenance of proper tensions, plus precision in adhesive application, give Inta-Roto laminators production speeds of 1000 feet per minute, with full quality control.

3. Your Inta-Roto laminator is completely assembled at our plant before shipment, for a test run using your materials; and at this time we check your men out on the running of the machine.

4. Inta-Roto ships the complete machine. There are no parts to wait for from various points in the country. You can assemble it at once and thus get into production faster.

5. Inta-Roto offers independent machines for separate laminating operations, or in-line units for use with other equipment. Combination laminators are also available for laminating and coloring or coating in the same operation.

6. Inta-Roto laminators are built on the unit principle. By this method, the machine can be modified to meet added requirements of production and other units may be added at a later date.

7. Inta-Roto laminators are designed for laminating with aqueous or solvent type adhesives or with hot melts.

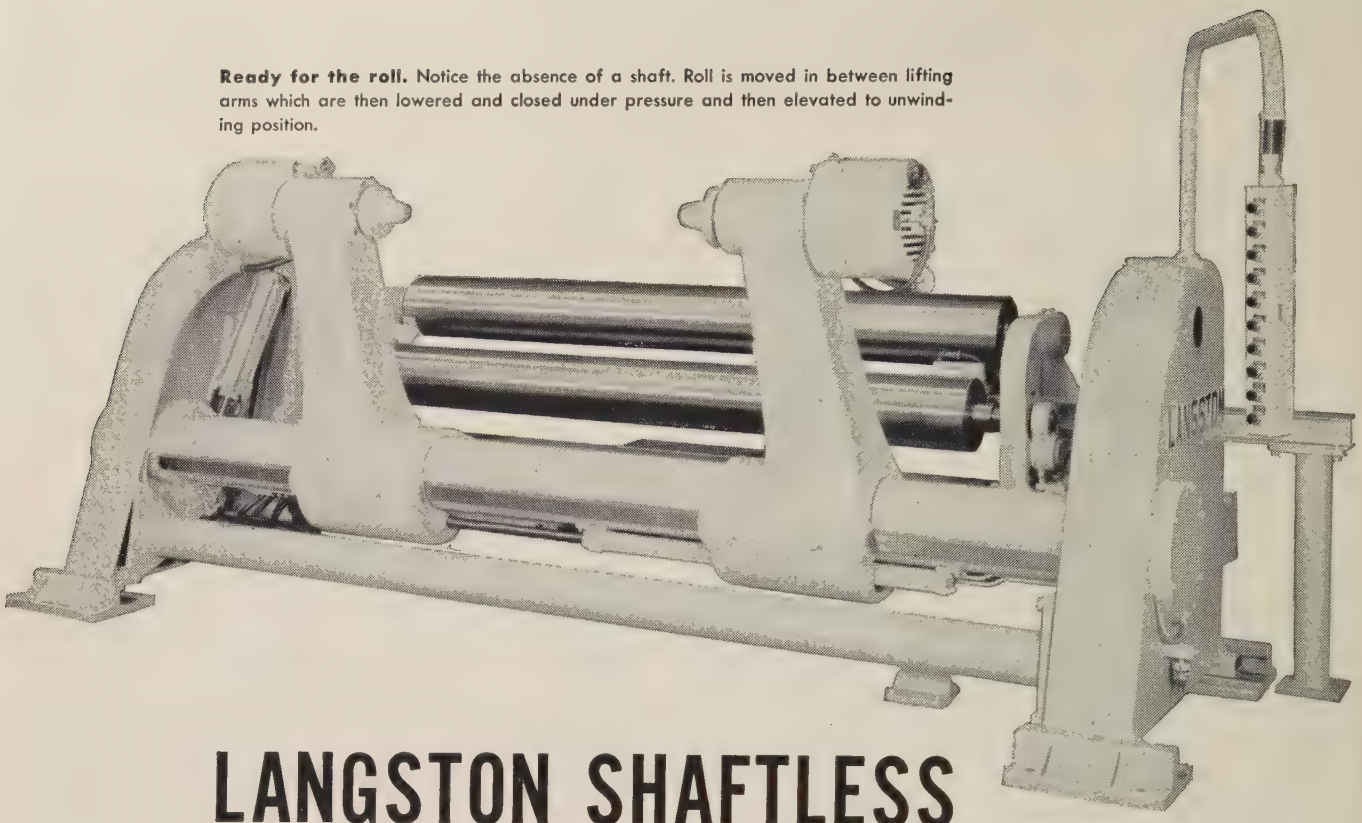
8. Although Inta Roto makes equipment for the giants of industry, it gives every bit as much attention to the detailed needs of the smallest converter.

For further information about laminators for your particular operation, write:

INTA-ROTO
MACHINE COMPANY, INC.
P. O. Box 454, Byrd Airport, Richmond 3, Va.
Telephone: REpublic 7-4181

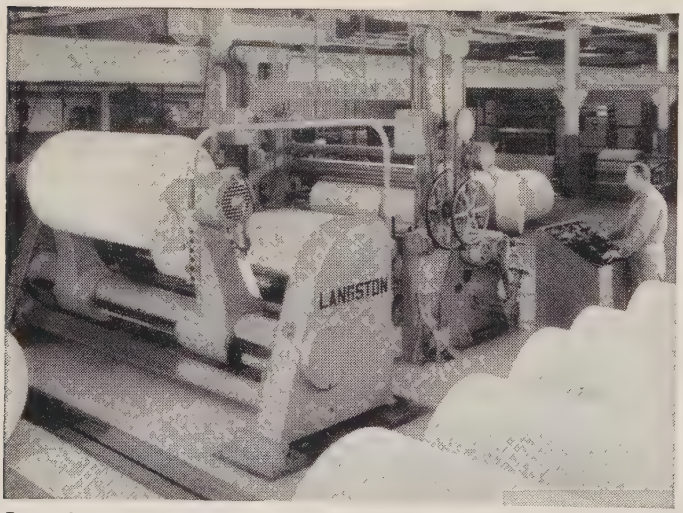
Manufacturers of rotogravure presses, laminators, slitters, rewinders and other precision machinery for the converter.

Ready for the roll. Notice the absence of a shaft. Roll is moved in between lifting arms which are then lowered and closed under pressure and then elevated to unwinding position.



LANGSTON SHAFTLESS UNWIND STAND

Boost your production . . . reduce your slitting and rewinding costs



Easy, fast, completely safe. One man does everything. Operating push-button controls, he closes lifting arms, elevates roll, sets brakes.

One man can load the heaviest roll. No heavy shaft to handle. No cone tightening. No couplings to engage. No crane lifting. Just pushbuttons. This is the Langston standard shaftless unwind stand for rewinding and converting applications.

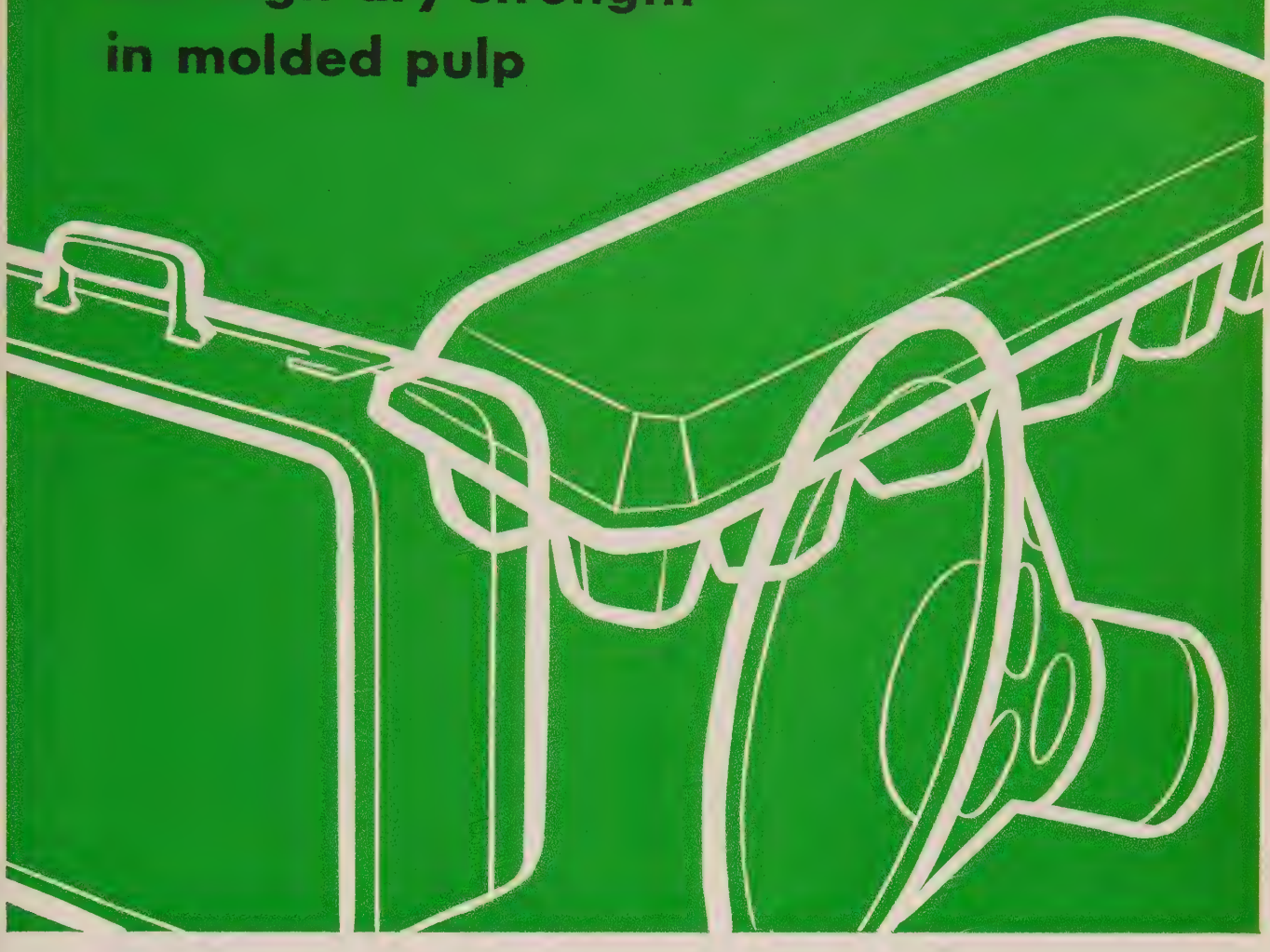
You not only save time, you also get better unwinding. Roll can be positioned laterally by push-button control—even when the machine is running. It's held firmly under pressure for complete safety throughout the unwind. Several braking arrangements can be provided to handle a wide range of grades and conditions. Available extras provide for handling very narrow rolls; for constant tensioning; for automatic braking of idler rolls; for automatic web alignment and side register control; for web oscillation; and for local or remote control.

This new Langston shaftless unwind stand can be used with any make of slitter. Available for maximum roll widths from 36 to 140 in. and diameters from 14 to 84 in. For complete information, write Samuel M. Langston Co., Camden 4, N. J.

SHEAR CUT CLEAN CUT

LANGSTON *Leadership...by design*

For high dry strength in molded pulp



Shawinigan GELVA® polyvinyl acetate emulsions

When toughness and rigidity are properties necessary in your molded pulp products investigate GELVA emulsions. Substantially increased strength and stiffness can be obtained with relatively small quantities of emulsion. The chart, right, presents data based on laboratory tests performed with three GELVA emulsions representative of Shawinigan's diversified line.

Shawinigan's products for paper applications include both GELVA polyvinyl acetate emulsions and resins and GELVATOL polyvinyl alcohol resins. A wide variety of standard grades is always available. Shawinigan's research staff and laboratories are ready to assist you with formulations for special applications. Write to Shawinigan Resins Corporation, Dept. 8S, Springfield 1, Massachusetts.

	% Resin add-on (dry)	Flexural Strength lbs/in²	Relative Rigidity	Gain in weight 24 hrs water immersion at 25°C.
Control — no resin additive	0	3000	1.00	240%
Gelva Emulsion S-51	10	6330	1.97	115%
Gelva Emulsion C-3	10	5520	1.91	140%
Gelva Emulsion S-55	10	4480	1.43	136%

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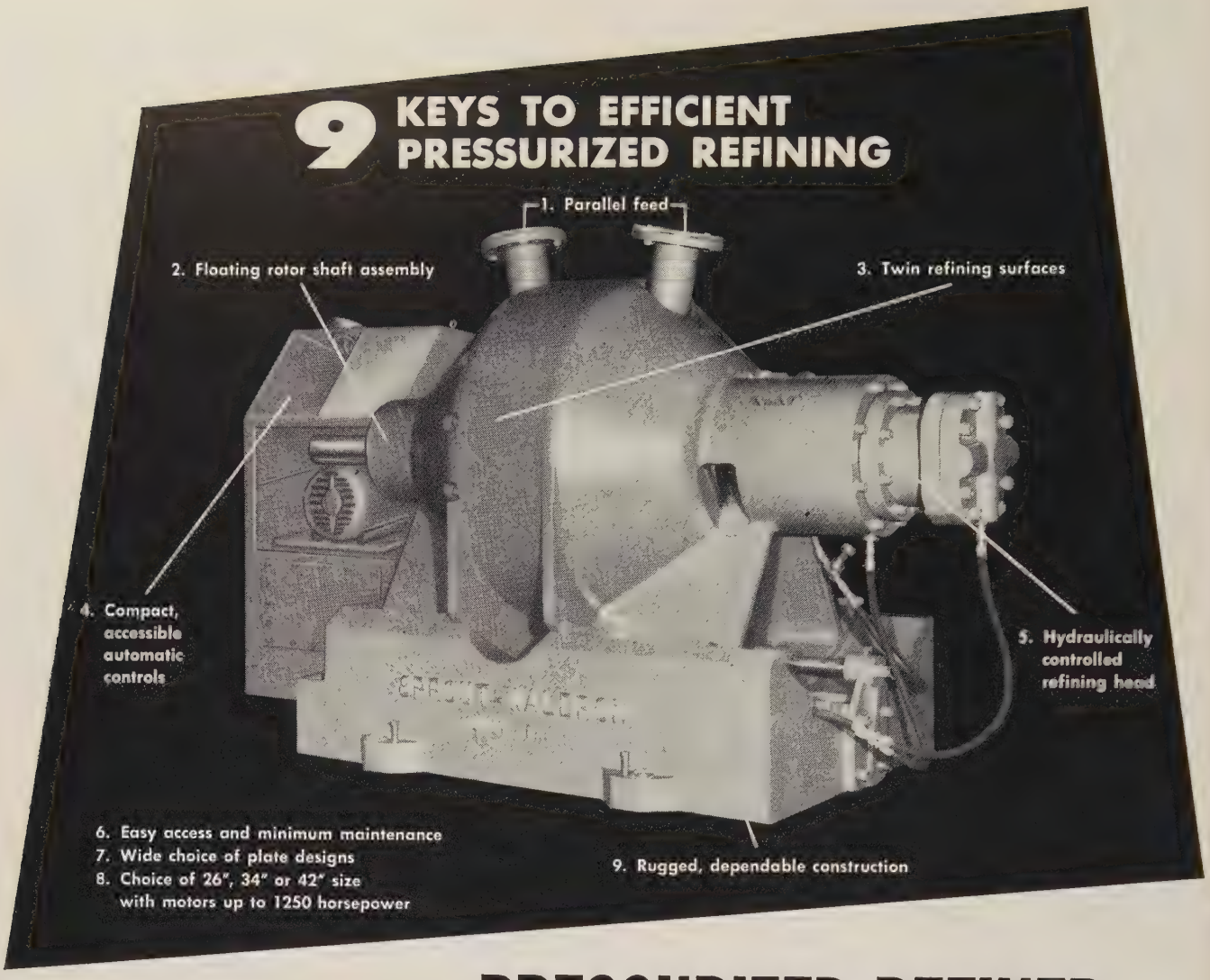
GELVA® *polyvinyl acetate emulsions by* SHAWINIGAN RESINS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twice the normal capacity in a single unit

Those in the know were quick to choose THE NEW PRESSURIZED "SPROUTS"

Here is a different type stock preparation refiner designed for superior quality control, low operating costs and minimum maintenance. The parallel feed arrangement serves twin refining surfaces, giving twice the capacity of single disc units. Key to refining accuracy and dependability is the floating rotor shaft disc assembly which rotates between the fixed and hydraulically controlled movable heads. The flow of pulp is equally distributed between both sets of plates, assuring uniform refining and even plate wear. If you are looking for mechanical simplicity, high production and uniform quality, plus low operating and maintenance costs—get the facts on the Sprout-Waldron 20", 26", 34" and 42" pressurized refiners. Bulletins available on request.

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E/209

Don't Tackle "Alligatoring" with a Blunderbuss!

use **Penford Gum**

Among the conditions that can interfere with the printability of coated paper is patterning—or "alligatoring" as it is sometimes called. This surface mottling may pass unnoticed until the paper is printed, then show up clearly in screened and solid-color areas. When you convert starch yourself, you risk "alligatoring"—and rejected orders because of it.

Fortunately, this condition can be avoided with starch derivatives, the Penford Gums, the modern approach to coating problems. Modern because a Penford Gum is made to order for your needs, to strictly controlled viscosities, and is uniform all the way through. The strong adhesive quality of Penford Gum allows the use of less binder and more pigment, while its improved dispersing property distributes pigment effectively. And because of Penford Gum's exceptional bound-water content, the coating remains on the surface long enough to be leveled uniformly.

These are just a few of the reasons why you get stronger, more even coatings with Penford Gum and hence greatly improved printability in your sheet. One of our technical service representatives will be glad to come to your plant to show you how Penford Gum can help you improve your paper without increasing costs. Call or write Penick & Ford today.

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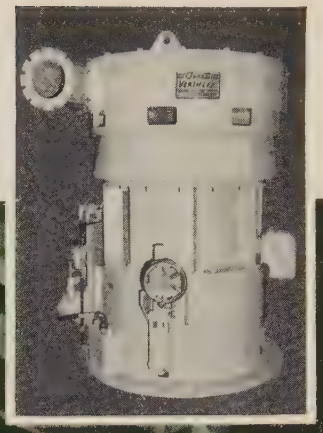
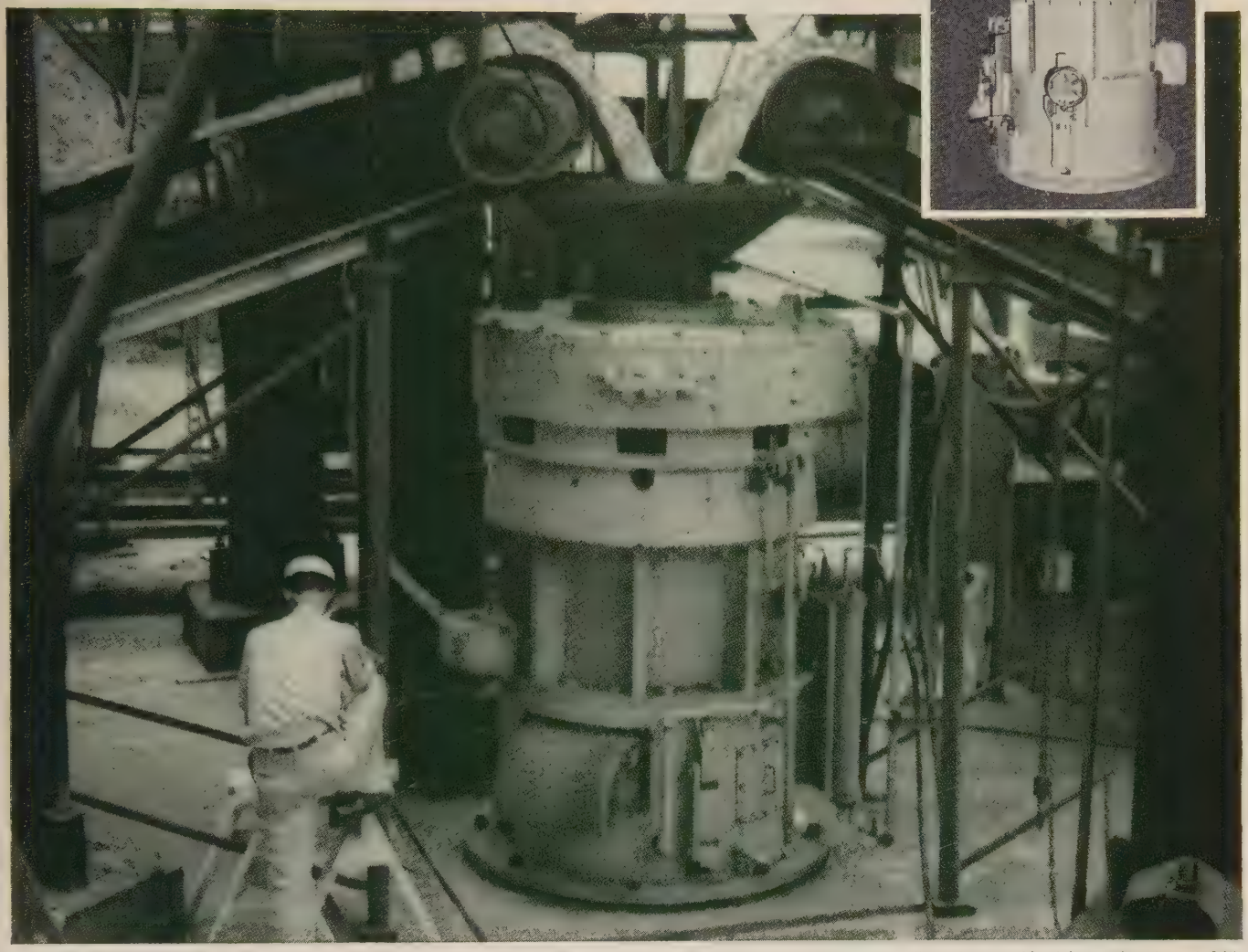
New Jones Vertiflex®





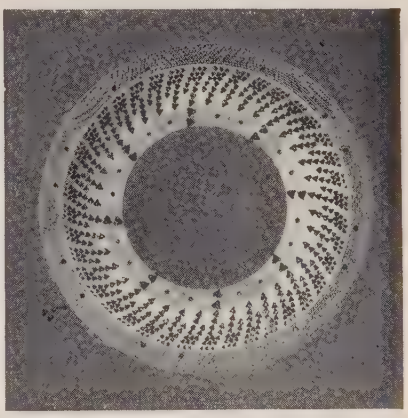
Vertiflex requires minimum floor space. Available in two disc sizes — 48" (shown here) and 34".

Typical application . . . . . Chip Shredding

High quality pulp with extremely low waste and fibre damage, substantial savings in alkali used, increased yield, decreased screen rejects and lower recovery system loading — those are the results from this efficient Jones Vertiflex chip shredding installation. And energy required to process more than 2000 B.D. tons per day is just over ¼ HP days per ton!

Full size chips are fed to the Vertiflex by belt conveyors from two chip silos. Resulting "shreds" are as long as the original chips, but greatly reduced in cross section.

Other applications on which the Jones Vertiflex will perform with outstanding efficiency include cold caustic chips, high yield pulps, bagasse, high density bleaching and denoodling. For full details write to E. D. Jones Corporation, Pittsfield, Mass.



Teeth in vertically mounted rotating disc inter-mesh with teeth in opposing stationary plate mounted in Vertiflex cover. Clearance is easily adjustable and disc life is high since there is never any metal-to-metal contact. Teeth shape and arrangements are varied to fit the application.

E. D. JONES CORP. PITTSFIELD, MASS. member BELOIT STONE

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starting point of your customized dextrins.

You get what you want and need—made to your specifications and designed to solve individual adhesive problems in your plant—when you get together with Clinton. And once you decide on a Clinton dextrin or combination, a whole area of worry disappears for you. Because you're *sure* of getting the same uniform quality from then on . . . no matter how large the *quantity* you order.

A Clinton Technical Sales Representative welcomes the opportunity to be of service to you. If you have a dextrin problem, your local Clinton Man will be happy to arrange a meeting.

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Use them for...

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things to do ~~today~~ NOW!

Slime formation in pulp and paper mills is an annoying situation any way you look at it, but at times and under certain operating conditions this problem can become all the more acute.

Whether chronic or acute, you can do something about the slime problems in your mill . . . *NOW* . . . through the use of an *effectively* planned program of microbiological control . . . ONE of the many services offered by Betz Laboratories.

For over 35 years, Betz has provided specialized consulting engineering service to the paper industry including the use and application of

- slime control agents
- pitch dispersers
- anti-scaling agents
- retention aids
- filming amines
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Like to know more about the Betz approach of microbiological control in pulp and paper mills? Bulletin 592 contains the facts. Write for a copy today.

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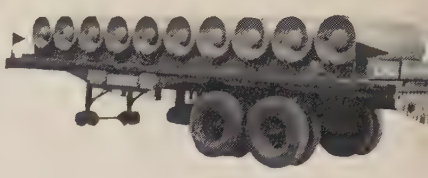
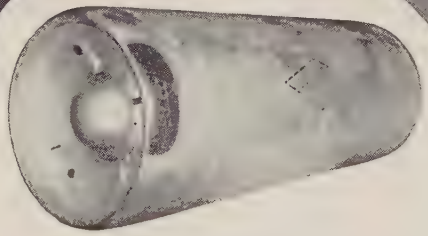
Single-unit tank car
16-, 30- or 55-ton capacity. Cars are lap-welded steel construction. Only opening is in dome which contains all valves.



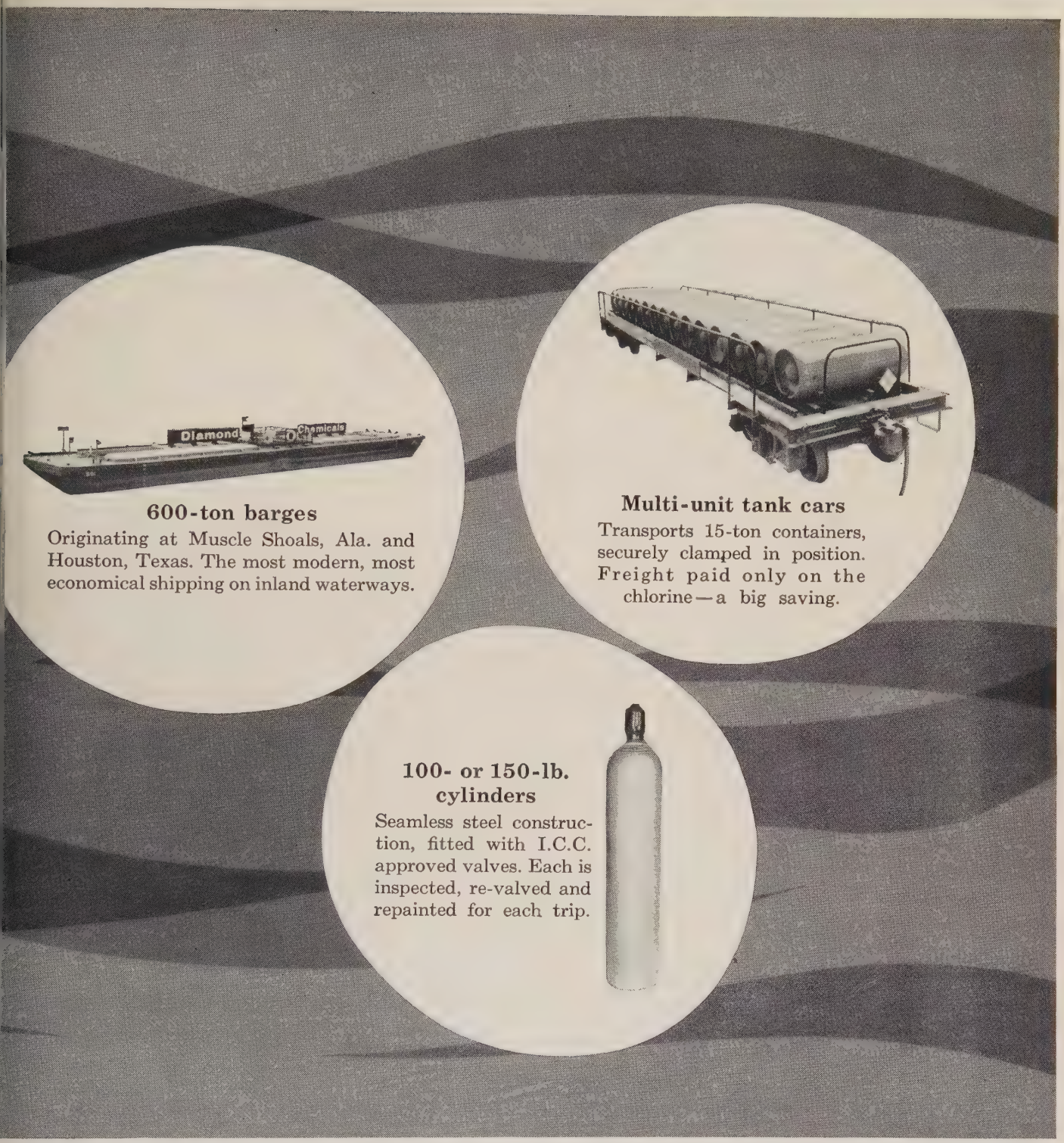
Multi-unit truck trailers
Lots of 6, 8 or 10 containers securely clamped in place on specially designed truck-trailer.



One-ton containers
Steel construction with approved valves. Completely inspected, re-valved and repainted for each trip.

how will you have your liquid chlorine?

Your source of Liquid Chlorine is the most important thing about it!



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Multi-unit tank cars
Transports 15-ton containers, securely clamped in position. Freight paid only on the chlorine—a big saving.

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Seamless steel construction, fitted with I.C.C. approved valves. Each is inspected, re-valved and repainted for each trip.

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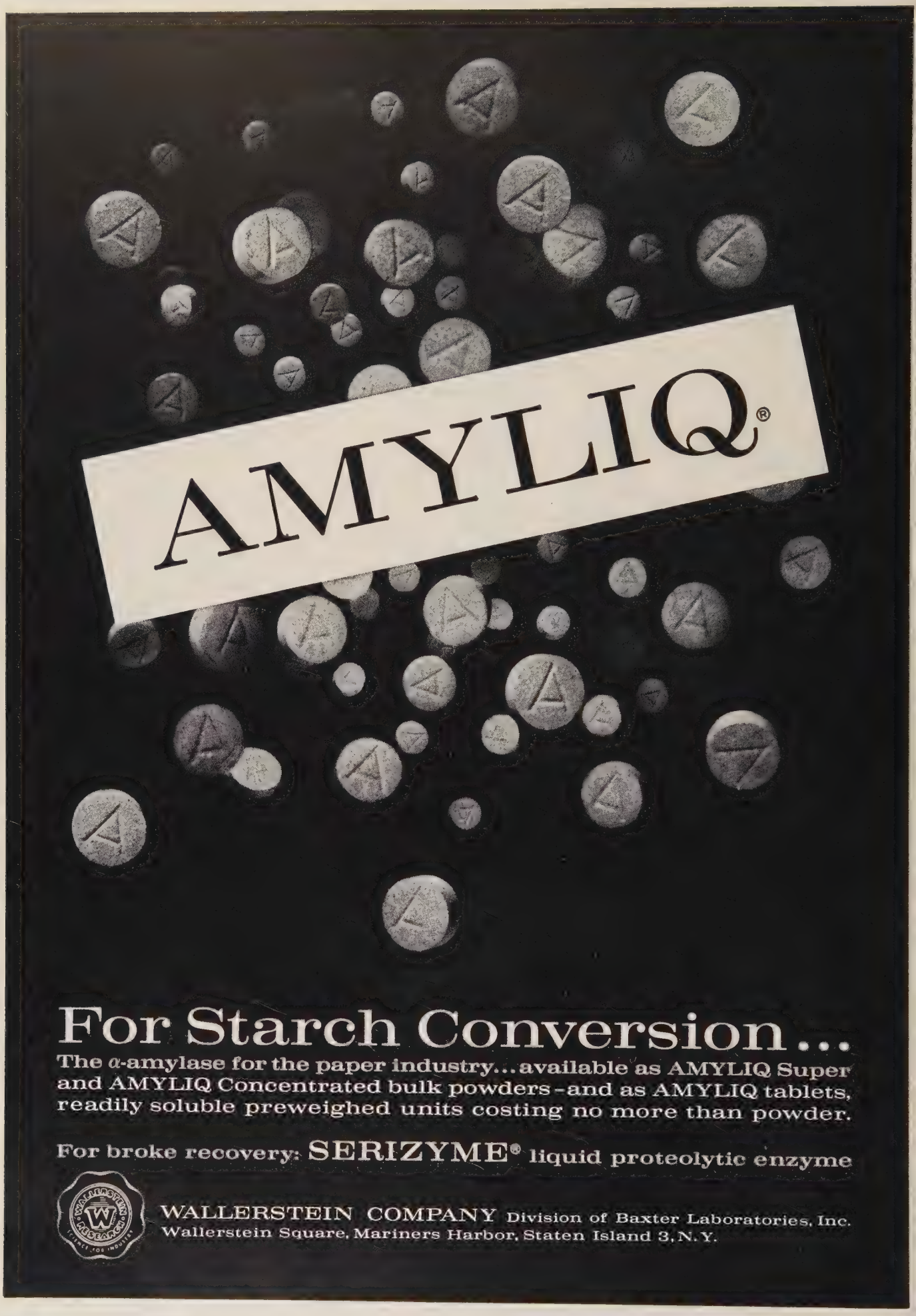
Diamond Chemicals®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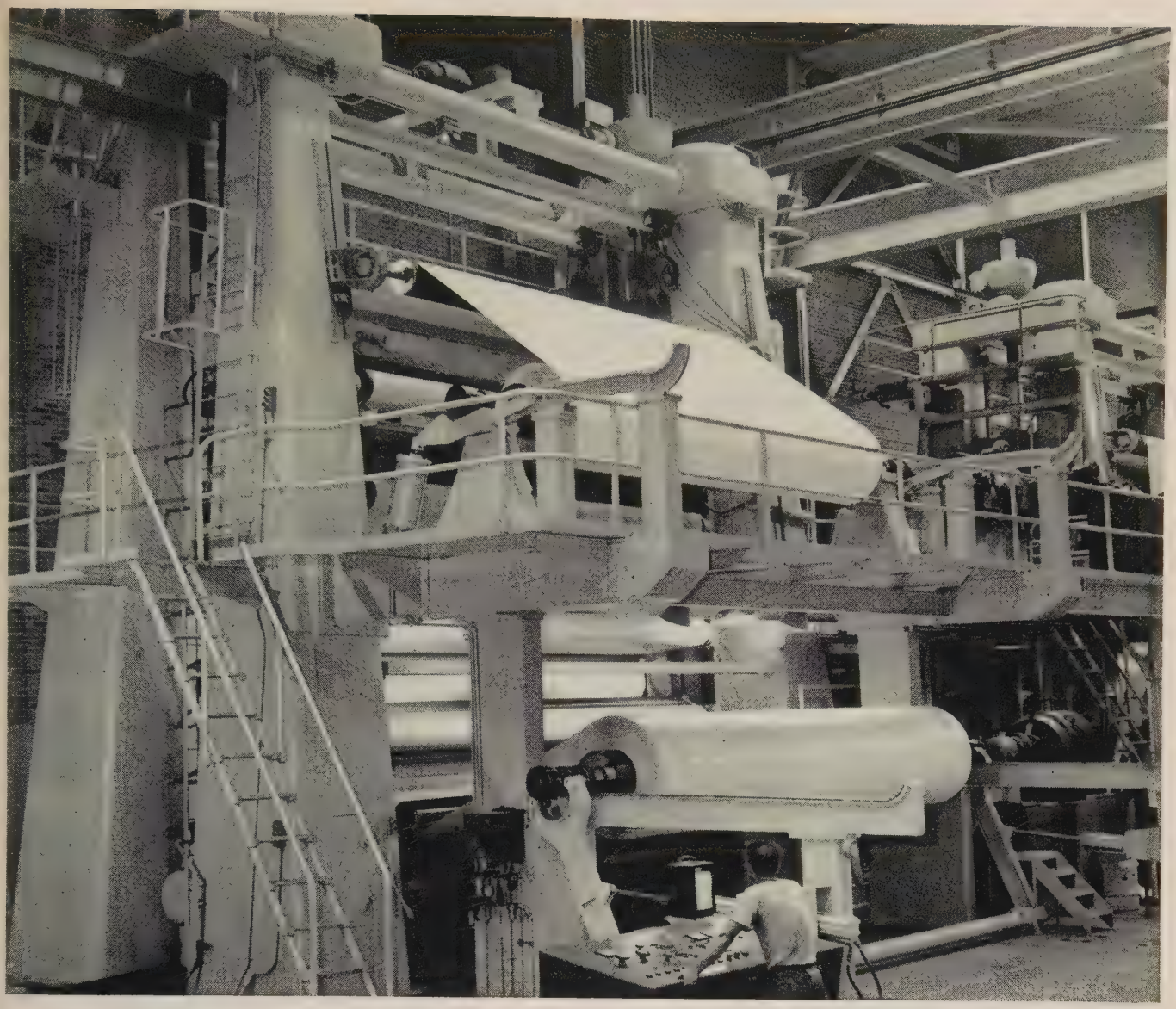

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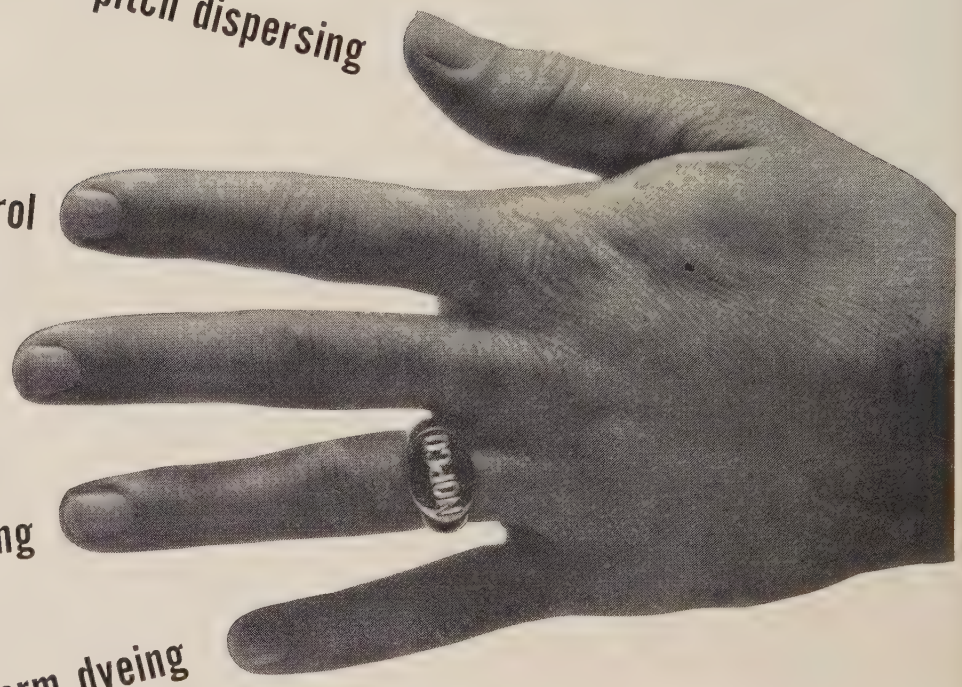

You will find it worth your while to get all the facts about Nopcosant—Nopco's newly improved dispersant and solubilizer. Ask your Nopco representative or write for complete information. Remember, too, back of every chemical made by Nopco for the paper industry stands Nopco Technical Service—an experienced staff ready to assist with laboratory data and recommendations based upon your specific requirements.

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A fine powder of uniform particle size

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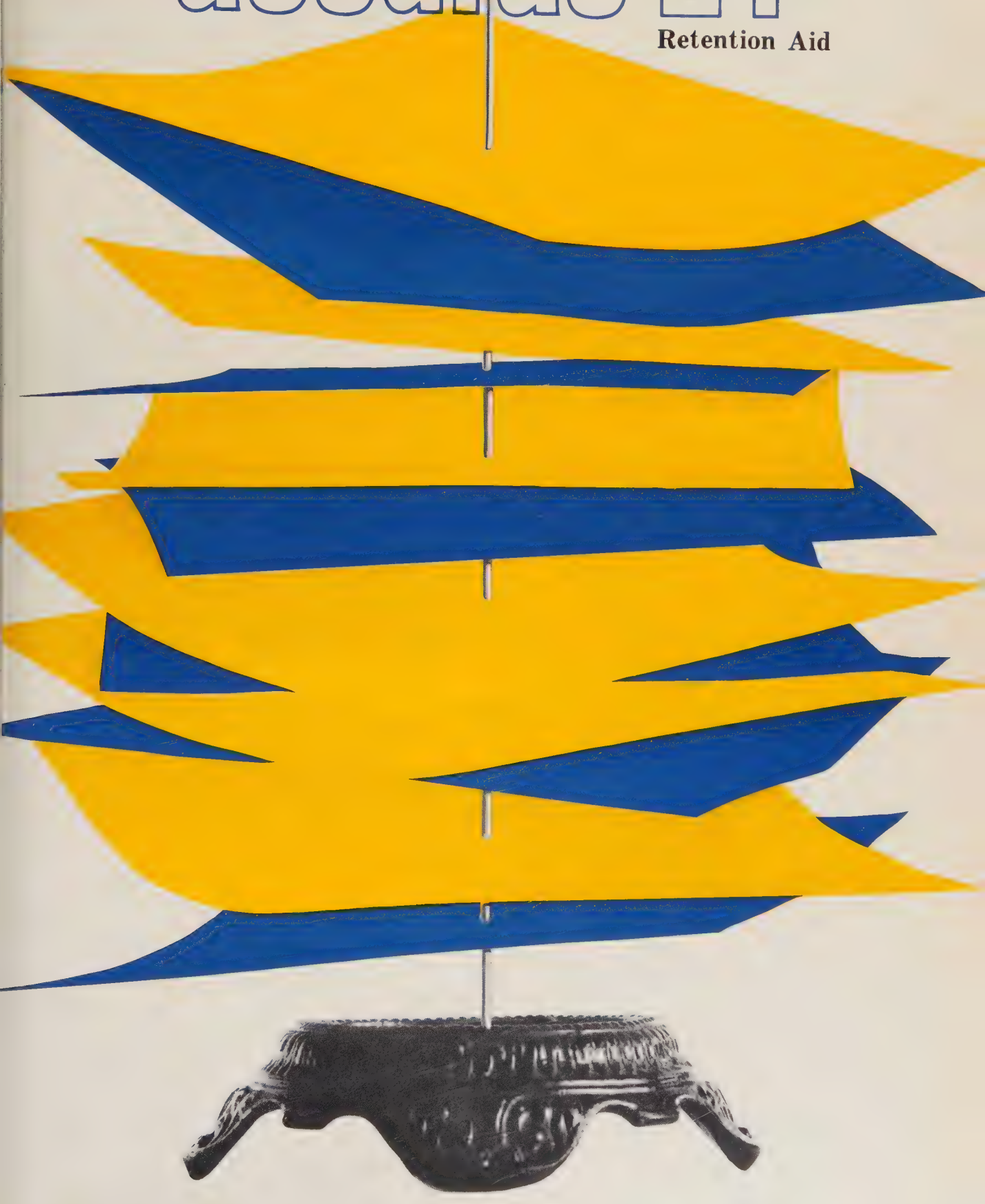
Retention Aid



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Retention Aid

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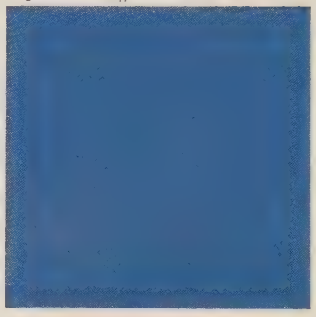
SQUARE #2–.25 lbs. per ton

SQUARE #3–.5 lbs. per ton

SQUARE #4–1.0 lbs. per ton

SQUARE #1–0

SQUARE #2–.25 lbs. per to



SQUARE #3–.5 lbs. per ton

SQUARE #4–1.0 lbs. per t

Each block contains equal amounts of blue or yellow pigment. The ACCURAC 24 content varies from zero to 1.0 pounds per ton of paper as indicated. Color specifications may be maintained by adding ACCURAC 24 in appropriate amounts while reducing the amount of pigment added to the stock. Or, additions of ACCURAC 24 to a given amount of pigment will intensify the final color.

Note the advantages of ACCURAC 24! Aids retention of fillers and costly pigments such as TiO_2 and colored pigments. Same color specifications with less pigment added. Retention of fines for improved formation of the sheet. Less fines in white water. Less load on save-alls. Less 2-sidedness in colored paper. Faster machine drainage. ACCURAC 24 is being successfully used in the paper industry to improve the retention of fines and pigments. For full information, send for Cyanamid's data sheet on ACCURAC 24.

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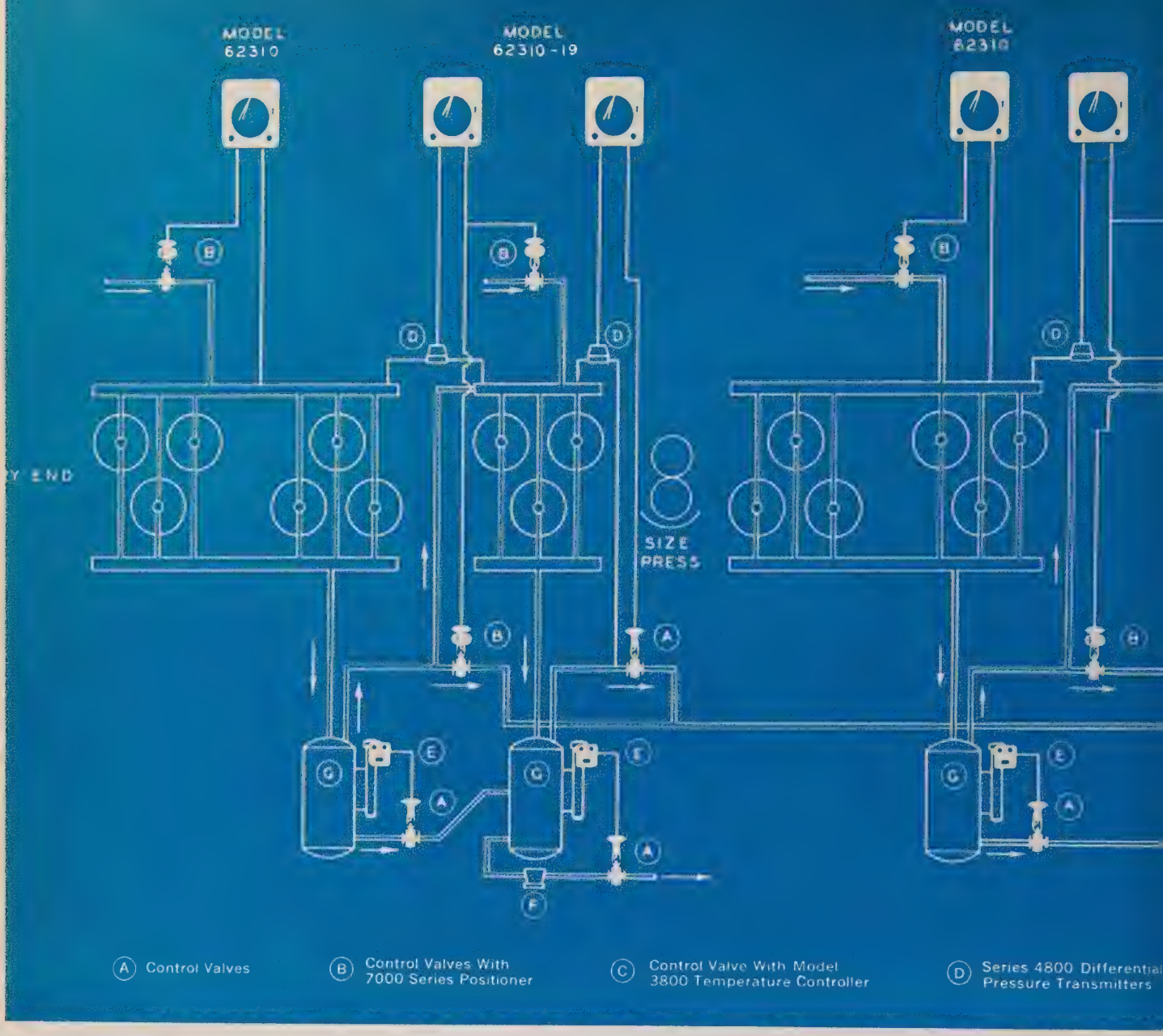
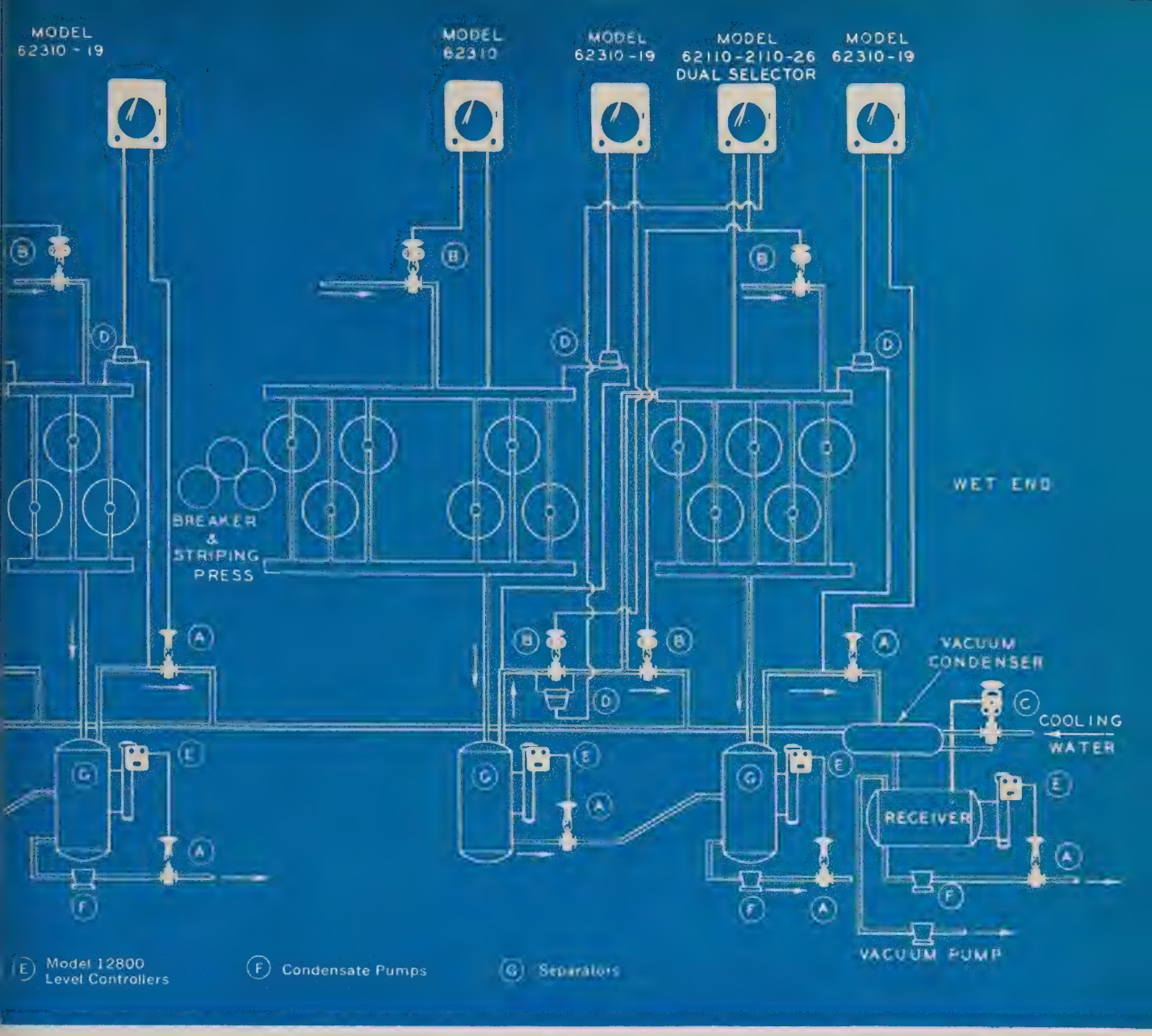


Quality + Efficiency in Papermaking



. . . with MASONEILAN Drying and Drainage Systems

An essential element in the production of quality papers s proper drying — obtainable only through accurately ontrolled steam, efficiently applied to driers.

Masoneilan Drying and Drainage Systems are individ-ally engineered for each paper machine to provide accu-ate control of steam pressure to the driers and continuous vacuation of condensate, air and non-condensables from ll driers, through means of closely controlled differential ressures. This insures improved paper quality, reduced onnage losses, maximum drying efficiency, and increased achine speed and flexibility.

These systems are available for Single and Multiple Section Paper Machines and for Yankee Driers, including Warm-up Control and Automatic Surface Temperature Control. Mason-Neilan engineers the systems and furnishes all equipment and controls — one source and undivided responsibility — for both new and rebuilt machines.

Send for Bulletin PD 113 . . .

for descriptions of basic Masoneilan Control Systems and related equipment; and for cooperation in engineering, contact a Masoneilan representative or write direct.

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Only an alkaline-sizing agent could be used, and Aquapel® sizing agent was the logical choice. Aquapel is more than a conventional paper size. It becomes an integral part of the paper. Since it is on the alkaline side, the paper is stronger and more durable.

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PP60-4

A Nalco PRODUCT MANAGER

Answers Questions About Slimes in Pulp and Paper Mills

Facts about a tough, continuing paper mill problem

Slimes are expensive—whether they slow production, spot finished paper, produce foul odors, increase maintenance time and expense, or corrode equipment, they cost the papermaker money. Here are a few of the more common questions about papermill slimes and slime control, answered for you by R. E. Eddy, product manager of Nalco Chemical Company's paper chemicals department.

Question: What Are Slimes?

Answer: Microbiological slimes are deposits of substances exuded by microorganisms, and chemical slimes are accumulations of water-borne fibers and chemicals. Microbiological slimes serve as a binder for chemical slimes, which in turn harbor the microorganisms which produce microbiological slimes. Slimes, however, are *not* microorganisms, but rather are substances produced *by* microorganisms.

Question: Why is slime control difficult in the paper industry?

Answer: Because paper mill systems provide the food supply, moisture, darkened recesses, and temperatures ideal for slime growth. Some organisms, not considered slime-producers in other industries, become of serious concern to the papermaker because of these ideal growth conditions.

Question: How can slime be controlled?

Answer: By establishing and maintaining a complete slime control program, to include chemical and physical analyses of the troublesome deposits, a survey of the paper mill system, and the application of chemical and mechanical slime control methods.

Question: What are the major considerations in a slime control program?

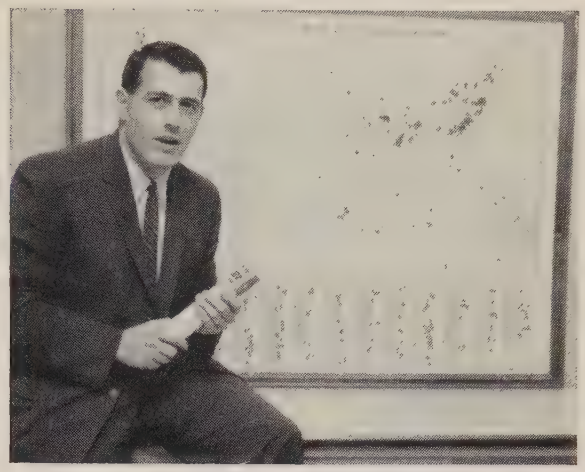
Answer: Types of organisms, points of infection, and flow of infection. Microbiological analysis of slime deposits shows which particular slime-forming microorganisms (spore formers, non-spore formers, fungi) are present in a given system, and analysis of stream samples points out centers of infection and flow of infection. In addition, an overall engineering survey of the entire system should be made, including flow diagrams, information on chemicals and raw materials used, water consumption rates, points and quantities of white water usage, system temperatures, and pH conditions. All of this information is then coordinated into a program of control.

Question: Who does the coordinating?

Answer: Your Nalco field representative can do it for you. Working in your mill, with your personnel, he will determine the best overall slime control program for your particular system. In addition to his own skills and experience in slime control, the Nalco field representative has the skills, experience, and facilities of Nalco's laboratories to call on if necessary.

Question: What does Nalco offer in the way of slime control?

Answer: A wide variety of quality products, excellent customer service, and a solid foundation of slime-control experience and knowledge. Nalco slimicides are available for use under any number of conditions —against different types of slime formers, in acid or alkaline operations, for continuous, intermittent, or slug feeding. No single slimicide can control all kinds of slime under all conditions, but your Nalco field representative can find the right combinations of slime-controlling chemicals for your mill, and determine the most economical method of application. The Nalco field representative will serve as a slime-control consultant—and even if there is a question he isn't able to answer immediately, he knows where to go to get the information he needs: Nalco's laboratories.



R. E. Eddy, Product Manager
Paper Industry Chemicals Department

Question: Why are there occasional flare-ups of new types of slime, even where a slime control program is in effect?

Answer: Because microorganisms compete for food. As one type of microorganism is eliminated, more food becomes available for other types. Other organisms get more food, thus flourish. Also, new types of microorganisms may be carried into the mill system via air, water, or raw materials. That's why a slime control program must be a continuing effort, ready to counter and destroy any new type of organism as soon as it appears.

Question: What's new in slime control?

Answer: Among other things, Nalco's organo-sulfur slimicides, available in liquid (Nalcon 242) and solid ball briquette (Nalcon 245) form. These Nalcon slimicides are effective additions to Nalco's proven line of slime control chemicals.

Question: What are Nalcon slimicides?

Answer: A combination of a powerful organo-sulfur microbiological agent and anionic dispersants. The organo-sulfur agents destroy slime producers (especially effective on non-spore formers) and the anionic dispersants have a dual function – they carry the organo-sulfurs to every part of the system, and they break up deposits of chemical slime. Nalcon slimicides aren't retained in finished paper, are non-phenolic and non-metallic. They have also been approved by the U.S. Food and Drug Administration for use in the manufacture of paper products to be used for food packaging.

Question: How quickly can an effective slime control program be established?

Answer: As quickly as you wish. Call your Nalco representative for prompt action, or write me for further details: R. E. Eddy, Product Manager, Paper Industry Chemicals Department.

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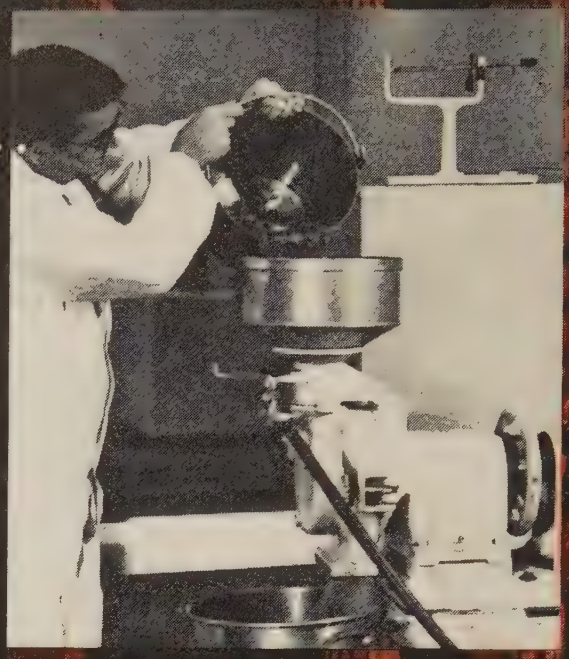

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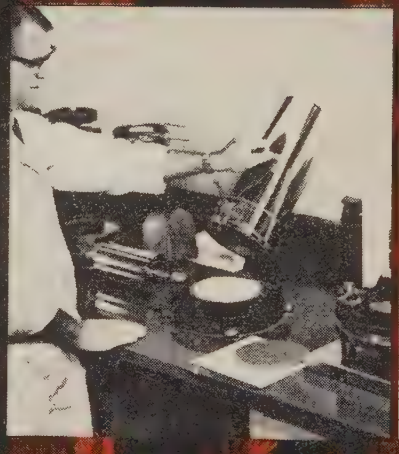

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Effect of Elevated Temperatures on the Neutral Sulfite Pulping Process

W. Z. WALTERS and M. N. MAY

In an effort to study the independent effect of pulping temperature on the chemical reactions involved in the NSSC pulping of aspenwood, an isothermal digester was developed, which was capable of heating or quenching the chip charge over a wide temperature range within a few seconds, thus approximating "isothermal" cooking conditions. Five such cooks were made at each of four temperatures (173, 186, 200, and 210°C.), the cooking time being varied so as to space pulp yields over the range of 45 to 75%. Based on chemical and physical properties, the following temperature effects were observed in pulps of equivalent yield: Increasing the cooking temperature greatly accelerated the rates of the chemical reactions normally associated with neutral sulfite pulping. Over a 37° range in cooking temperature, the increase in residual lignin was about 1%. Increasing the cooking temperature decreased the average D.P., the pentosan content, and the amount of alkali-soluble material remaining in the pulp, but did not affect the amount of alkali-resistant material. Tear factor and opacity were increased slightly, and tensile strength, stretch, and brightness were decreased slightly at higher cooking temperatures. At the same degree of beating, high-temperature pulps had a slightly lower intrinsic fiber strength and a lower fiber-to-fiber bonding capacity than did low-temperature pulps.

Partially as a result of continuous pulping techniques (*1*) there has been an increasing interest in reducing the digestion time for the neutral sulfite process. In the pulping temperature range of 140 to 180°C., the neutral sulfite pulping reaction behaves like many organic reactions, in that the pulping rate approximately doubles for each 10°C. increase in reaction temperature (*2–5*). However, several investigators (*2, 6–8*) state that at very high temperatures (above 170°C.), pulps of the same yield have less carbohydrate and are more degraded than those produced at lower temperatures. If this is true, accelerated reactions at increased temperature might be undesirable.

However, this effect of elevated temperatures is open to some question. Data in many cases were obtained from comparisons of pulps produced at different cooking temperatures but not at equivalent yields. Furthermore, the periods of heating and quenching the digester were often ignored or omitted in the determination of reaction rates. Assuming that the pulping reaction rate does double with each 10°C. increase in temperature, four hours at 170°C. are equivalent to only seven and a half minutes at 220°C. Most batch laboratory digesters require more than thirty minutes to reach temperatures of even 180°C.; therefore, overcooking would occur if provisions were not made for very rapid heating and cooling in high-temperature studies.

Not all the reported data indicate excessive degradation at elevated temperatures. In the temperature range 140 to 180°C., the relative rates of removal of lignin, pentosans, and cellulose do not materially change with change of digestion temperature (*4, 7, 9–14*). It appears unlikely that the effect of temperature should undergo a marked change at higher temperatures.

The importance of the time-temperature relationship to degradation at elevated temperatures should be emphasized. In the Masonite process, where temperatures are in the range of 250 to 285°C. (*15*), one-half second difference in cooking time will greatly alter the fiber produced (*16, 17*). Cellulose itself can be converted to a black carbonaceous mass at temperatures of 290°C. (*9*) and gelatinization will occur at about 215°C. (*18*). However, by limiting the time at maximum temperatures, usable fibers have been produced at temperatures as high as 280°C. (*15, 18, 19*).

EXPERIMENTAL PROCEDURES

Five neutral sulfite cooks were made at each of four temperature intervals (173, 186, 200, and 210°C.) with a specially constructed isothermal digester. The use of this digester essentially eliminated the heat-up and quenching period and allowed precise control of the time-temperature factors.

Isothermal Digester Design

A schematic drawing showing the design of the isothermal digester can be found in Fig. 1 (more complete drawings are available from The Institute of Paper Chemistry). This equipment has the following operational features:

1. Two pressure vessels, numbered 1 and 2, were attached to one another by suitable piping. Vessel no. 1, the larger of the two, was for preheating the cooking liquor to temperature, while vessel no. 2 was that in which actual pulping was accomplished.
2. An appropriate liquor charge was introduced into vessel no. 1, where it was heated to the desired temperature by means of electrical heaters.
3. Wood veneer was packed into a specially designed stainless steel basket and this basket was inserted into vessel no. 2. After sealing, a vacuum (0.5 to 1.0 cm. of mercury total pressure) was applied to the vessel. This vacuum prevented heat transfer by convection from the vessel wall to the basket and its contents, and also had the desirable effect of removing the major portion of air entrapped within the cell walls of the wood. The basket was specifically designed to act as a radiation shield, thereby minimizing heat transfer to the wood by radiation. Metal-to-metal contact between the basket and the vessel wall was avoided, reducing heat transfer by conduction to a negligible amount.

W. Z. Walters, Graduate Student, The Institute of Paper Chemistry, Appleton, Wis., present address, The Beveridge Paper Co., Indianapolis, Ind., and M. N. May, Chief, Pulping and Papermaking Group, The Institute of Paper Chemistry, present address, Gulf States Paper Corp., Tuscaloosa, Ala. Work performed at The Institute of Paper Chemistry.

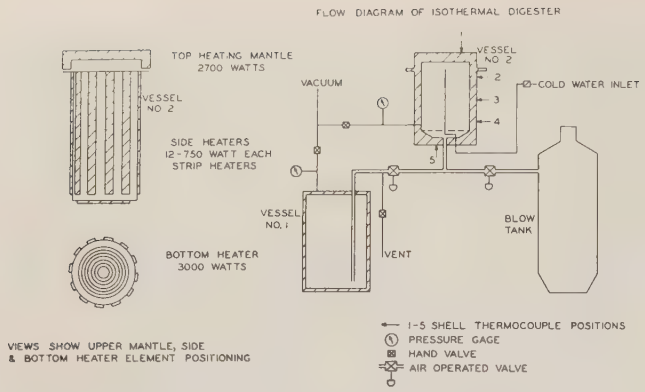

Fig. 1. Flow diagram of isothermal digester

4. After the liquor was preheated, the basket properly positioned, and the shell wall of vessel no. 2 heated to the proper temperature, the cooking reaction was started by opening the line connecting the two vessels. This allowed the hot liquor to transfer from vessel no. 1 to vessel no. 2. By proper manipulation of conditions in vessels nos. 1 and 2, a very rapid temperature change was brought about within the wood itself.

5. Upon completion of cooking, the liquor content of the entire system was dumped by opening the relatively large line leading to the cyclone blowpit. As pressure dropped, cold water was injected into the center of the pulp mass until such time as vessel no. 2 could be opened and its contents removed.

6. Four thermocouples of a Ceramo design were used to measure cooking temperature. These thermocouples were specifically constructed to possess a minimum heat capacity and when used with a Minneapolis Honeywell Brown Electronik Recorder, Type 153 potentiometer, measurement of temperature change was extremely rapid. The design of the chip basket permitted the insertion of the thermocouples directly into the mass of the veneer chips.

Figure 2 is a duplication of a temperature profile obtained by a continuous recording of potential from a thermocouple located in the geometric center of the chip mass. Examination of this data shows that both heating and quenching were accomplished very rapidly. Temperature measurements at different points in the chip bed showed that at any given time, the temperature variation throughout the chip charge did not exceed

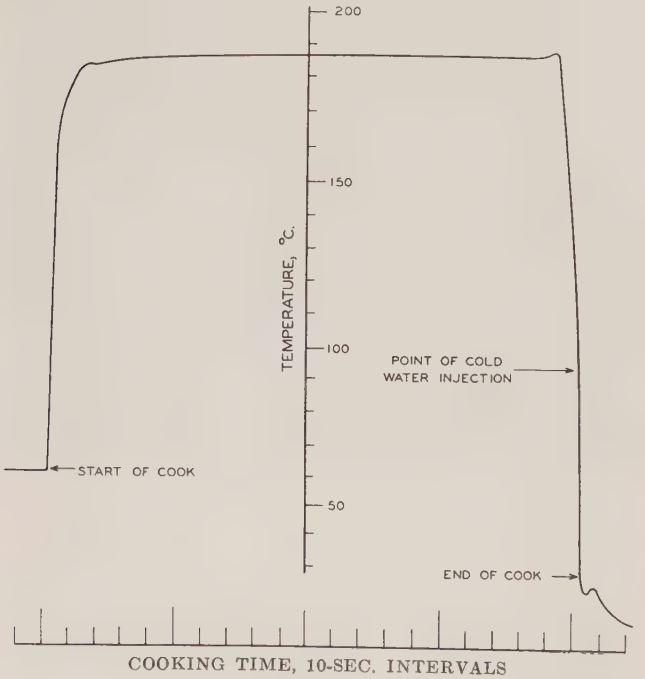

Fig. 2. Measured temperature curve. Cook no. 34

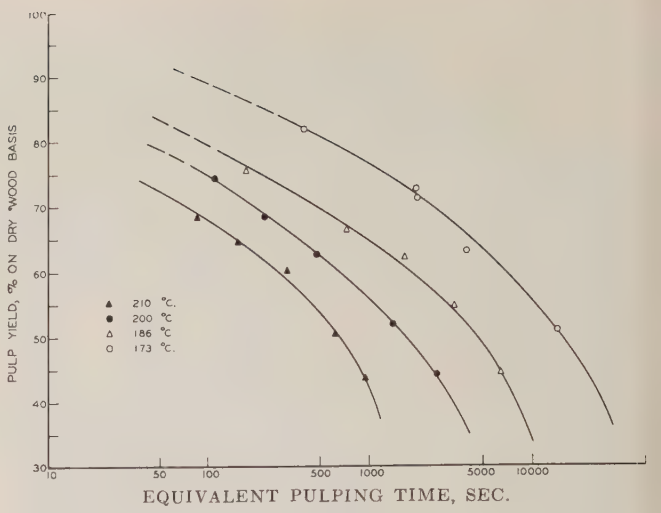

Fig. 3. Pulp yield vs. log equivalent pulping time

1°C. Temperature throughout a cook could be controlled to within ±1°C., and overall reproducibility on successive cooks was about ±1.5°C. Because of the shape of the temperature profile it was concluded that there was no great degree of precision for cooks of less than three minutes duration, and the minimum meaningful cooking time was approximately 90 seconds.

The wood used in the isothermal digester was aspen sapwood veneer. This veneer was obtained from selected trees and was cut into sheets 0.023 ± .001 in. thick (35–40 fibers in cross section). After air-drying, the sheets were cut into chips, 1 by 1 by 0.023 in. The cooking liquor consisted of a 110 g.p.l. solution of sodium sulfite and the digester was operated at a 13 to 1 liquor-to-wood ratio.

The pulps obtained were analyzed for both chemical and physical properties. The results of the chemical evaluation can be found in Table I.

The expression "equivalent cooking time," used in Table I, is the actual pulping time corrected for the minor temperature variations which existed in the isothermal digester.

PRESENTATION OF RESULTS

Yield

In order to illustrate the relationship of time-temperature-yield, a plot was made of yield versus the logarithm of equivalent cooking time (Fig. 3). The use of the logarithmic function was simply to reduce the time scale to reasonable proportions. Figure 3 aptly shows that increasing pulping temperature greatly reduces the time required to pulp to any given yield. Also, it is interesting to note the similarity in curvature between the isotherms obtained, as these data indicate the similarity in the pulping process with increasing cooking temperature.

Lignin Content

The sum of Klason lignin and ultraviolet measurements of the soluble lignin was termed total lignin. The effect of pulping temperature on total lignin content can be seen from a plot against pulp yield (Fig. 4). This figure shows that increasing temperature tended to increase slightly the amount of lignin remaining in the pulp when comparisons are made at equal yields.

Table I. Chemical Analysis

Cook no.	Temperature of pulping, °C.	Yield, %	Equivalent cooking time, sec.	Klason lignin, %	Ultraviolet lignin %	Total lignin %	Methoxyl content, %	Holocellulose, %	Viscosity determination, cp.	Pentosan content, %	21.5% Alkali resistant, %	21.5% Alkali soluble, %	10% Alkali resistant, %	10% Alkali soluble, %
32	173	81.7	397	10.1	4.1	14.2	3.62	64.7	29.5	14.6	53.9	10.8	51.5	13.2
31	173	72.3	1922	5.6	2.6	8.2	2.11	61.2	32.0	13.0	52.8	8.4	51.0	10.2
29	173	71.3	1961	6.0	2.7	8.7	2.24	60.2	37.7	12.6	51.4	8.8	48.5	11.7
39	173	62.7	4048	2.6	1.8	4.4	1.17	56.3	24.4	11.5	50.4	5.9	49.4	6.9
33	173	50.8	14556	0.3	0.6	0.9	0.29	48.3	8.8	8.0	42.9	5.4	41.5	6.8
34	186	75.1	172	8.1	3.7	11.8	2.93	61.4	...	12.1	53.2	8.2	51.1	10.3
36	186	66.1	703	4.5	2.2	6.7	1.77	57.4	22.3	10.7	51.4	6.0	50.2	7.2
35	186	61.9	1642	2.6	1.6	4.2	1.15	55.5	16.4	9.9	49.6	5.9	48.4	7.1
38A	186	54.3	3282	1.0	0.6	1.6	0.48	51.3	10.6	8.2	46.4	4.9	44.9	6.4
37	186	44.0	6495	0.2	0.3	0.5	0.13	42.5	3.9	5.9	37.8	4.7	35.9	6.6
40	200	74.5	118	8.9	2.8	11.7	3.05	59.5	36.9	11.5	51.9	7.6	50.6	8.9
42	200	68.9	222	6.0	2.4	8.4	2.12	57.7	26.7	10.1	51.4	6.3	50.1	7.6
43	200	61.8	457	3.6	1.8	5.4	1.36	54.1	18.0	9.3	49.1	5.0	48.0	6.1
44	200	51.7	1422	0.8	0.4	1.2	0.39	48.6	6.7	7.0	44.6	4.0	43.2	5.4
41	200	44.1	2598	0.2	0.4	0.6	0.01	42.5	3.8	5.2	38.5	4.0	36.4	6.1
47	210	68.2	84	5.8	2.3	8.1	2.14	57.3	17.2	9.1	51.2	6.1	50.1	7.2
46	210	64.6	149	4.6	1.0	5.6	1.65	55.7	15.0	8.7	50.6	5.1	49.5	6.2
49	210	60.1	303	3.0	1.4	4.4	1.21	53.7	12.6	8.2	48.8	4.9	47.8	5.9
48	210	50.3	560	0.9	0.7	1.6	0.39	47.1	4.8	6.4	43.4	3.7	41.5	5.6
45	210	43.9	896	0.6	0.3	0.9	0.01	41.8	3.3	4.8	36.4	5.4	35.0	6.8
Wood	...	100.0	...	17.8	2.7	20.5	...	75.4	...	18.7	64.9	10.5	61.7	13.7

Note: All percentages expressed in this table are based on the ovendry wood.

However, the indicated trends must be considered with some skepticism, as the temperature effect observed was small. Whether such a small change in lignin content could be definitely established by the testing procedures employed is open to some question. The data must be considered to indicate only a possible trend.

Methoxyl Content

In pulp the majority of the methoxyl groups should be contained within the structure of the lignin, and hence methoxyl content can be assumed to be related to lignin content. When the methoxyl data were plotted against pulp yield (Fig. 5), it was found that the methoxyl content was higher for high-temperature pulps. This supports the trends shown by the total lignin data.

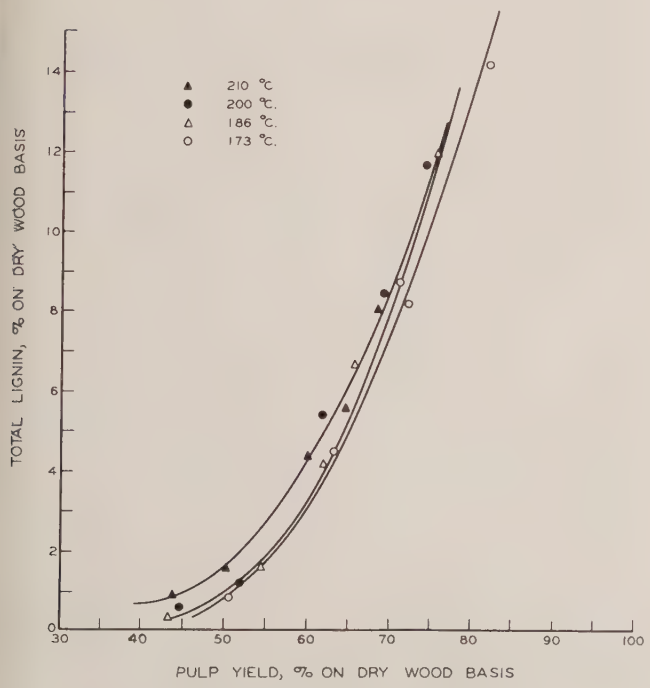

Fig. 4. Total lignin vs. pulp yield

Total Carbohydrate Material

A sodium chlorite holocellulose determination was used as a measure of the total carbohydrate fraction present. Figure 6 shows that as temperature was increased, pulps of equivalent yield contained slightly less holocellulose.

Alkali-Resistant Cellulose

Holocellulose pulps were treated with 10 or 21.5% sodium hydroxide solutions. The material which remained undissolved in the alkali was termed 10 or 21.5% alkali-resistant cellulose. Similarly, the material which dissolved in the alkali was termed 10 to 21.5% soluble carbohydrate.

The data obtained showed little if any pulping temperature effect on the amount (based on the wood) of alkali-resistant cellulose. However, increasing pulping temperature resulted in pulps containing a slightly lower per cent of alkali-soluble carbohydrate material. The concentration of alkali in the test affected the absolute value of the soluble material, but the relative effect of pulping temperature remained approximately constant for both 10 and 21.5% alkali.

Pentosan

When the pentosan data were plotted as a function of yield (Fig. 7), it was observed that increasing pulping temperature decreased the pentosan content when

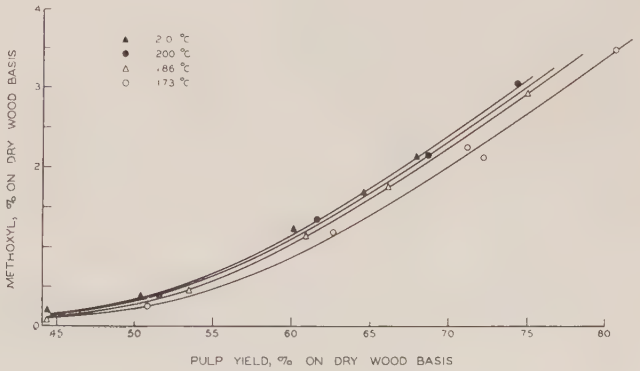

Fig. 5. Per cent methoxyl vs. pulp yield

Table II. Physical Evaluation of Pulps Produced at 173°C.

Cook no. and yield, %	*Beating time, min.*	*Basis weight, g./sq. m.*	*Caliper, mils*	*Apparent density, g./cc.*	*Tensile strength, lb./in.*[a]	*Corrected tensile, lb./in.*[b]	*Elmendorf tear, factor*[c]	*Corrected Elmendorf tear*[d]	*Clark rigidity, factor*	*Stretch, %*[e]	*Schopper-Riegler freeness, cc.*	*B & L opacity, %*[f]
Cook 32; yield, 81.7	5	65.95	4.0	0.65	22.9	28.3	77.3	95.5	89.3	2.00	830	72.0
	10	66.08	3.6	0.72	27.3	33.7	69.6	86.0	110.3	2.60	800	70.5
	20	65.67	3.2	0.81	31.7	39.1	64.0	79.1	146.3	2.97	670	68.0
	30	67.32	3.1	0.85	35.7	44.1	55.0	67.9	144.9	3.57	460	63.5
	40	65.35	3.0	0.86	36.9	45.6	56.6	69.9	145.9	3.57	405	62.5
Cook 31; yield, 72.3	5	64.67	3.5	0.73	34.4	39.6	74.2	85.3	131.1	3.13	850	72.0
	10	65.43	3.2	0.80	37.5	43.1	68.8	79.1	161.7	3.40	830	68.5
	20	65.77	3.0	0.86	42.3	48.6	63.9	73.4	171.2	4.07	720	62.5
	30	64.51	2.9	0.88	43.1	49.5	58.9	67.7	159.0	4.07	510	56.5
	40	65.40	2.8	0.92	46.0	52.9	56.6	65.0	180.8	4.33	410	53.5
Cook 29; yield, 71.3	5	66.17	3.6	0.72	32.4	37.6	78.6	91.3	138.3	2.67	855	73.0
	10	65.71	3.2	0.81	40.1	46.6	67.0	77.9	171.6	3.67	815	69.0
	20	66.20	3.1	0.84	41.4	48.1	66.5	77.3	173.6	3.53	675	64.0
	30	65.55	2.9	0.89	41.0	47.7	54.9	63.8	154.3	4.07	545	56.5
	38	67.14	3.0	0.88	43.2	50.3	56.6	65.7	158.4	4.27	395	49.5
Cook 39; yield, 62.7	5	65.92	3.4	0.76	39.5	43.3	72.8	79.7	164.4	3.40	830	73.5
	10	65.61	3.2	0.81	44.3	48.5	70.1	76.8	163.0	3.87	810	69.0
	20	66.30	3.1	0.84	45.8	50.1	64.9	71.1	171.8	4.03	720	64.5
	30	65.76	3.0	0.86	47.4	51.9	60.8	66.6	166.1	4.27	525	59.5
	40	65.43	2.9	0.89	44.4	48.6	65.7	71.9	177.0	3.73	465	58.5
Cook 33; yield, 50.8	5	64.81	3.3	0.77	34.7	35.9	83.3	86.4	174.7	3.03	780	74.5
	10	65.55	3.2	0.81	36.4	37.8	82.4	85.4	171.8	3.37	750	71.5
	20	65.30	3.1	0.83	40.1	41.5	82.7	85.7	175.4	3.83	650	68.5
	30	64.19	2.9	0.87	42.0	43.6	70.1	72.7	184.0	4.17	515	64.5
	40	65.09	2.9	0.88	40.3	41.8	75.3	78.1	182.0	4.00	445	64.0

[a] Tensile strength expressed in terms of pounds per inch at a sheet weight of 65.5 g. per sq. m.
[b] Corrected tensile expressed in terms of pounds per inch at a sheet weight of cellulosic material equal to 65.5 g. per sq. m.
[c] Tear factor expressed in grams of force required to tear a sheet of 100 g. per sq. m. basis weight.
[d] Corrected tear expressed in grams of force required to tear a sheet of 110 g. per sq. m. cellulosic weight.
[e] Stretch expressed as percentage elongation of specimen at rupture under tensile strain.
[f] B & L opacity = opacity by contrast ratio—100 $R_0/R_{0.89}$.

pulps were compared at equivalent yields. This decrease in pentosan content was considerable and for the overall temperature range studied amounted to approximately one-third of the pentosan material remaining in the pulp.

Cupriethylenediamine Viscosity

To obtain an indication of the degree of polymerization, the viscosity of a 0.5% solution of holocellulose in cupriethylenediamine was determined. These data indicate that the viscosity of the holocellulose fraction decreased with increasing pulping temperature. The viscosity of a 210°C. holocellulose was roughly half that of 173°C. holocellulose at comparable yields.

Pulp Physical Properties

Pulp from each cook was beaten in a Jokro mill for various time intervals and standard TAPPI handsheets were made. Physical tests were conducted on these handsheets and the results are shown in Tables II-V.

When comparisons were made at equal beating intervals and at similar yields, increasing pulping temperature was found to have:

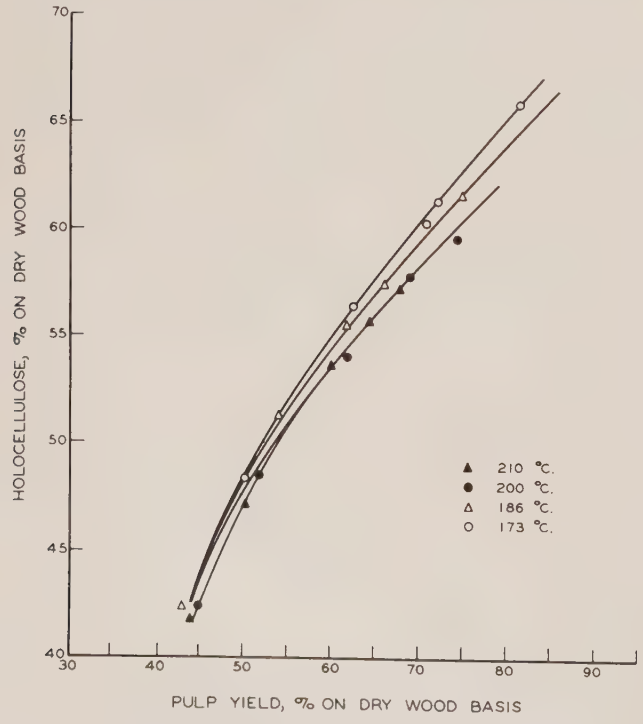

Fig. 6. Per cent holocellulose vs. pulp yield

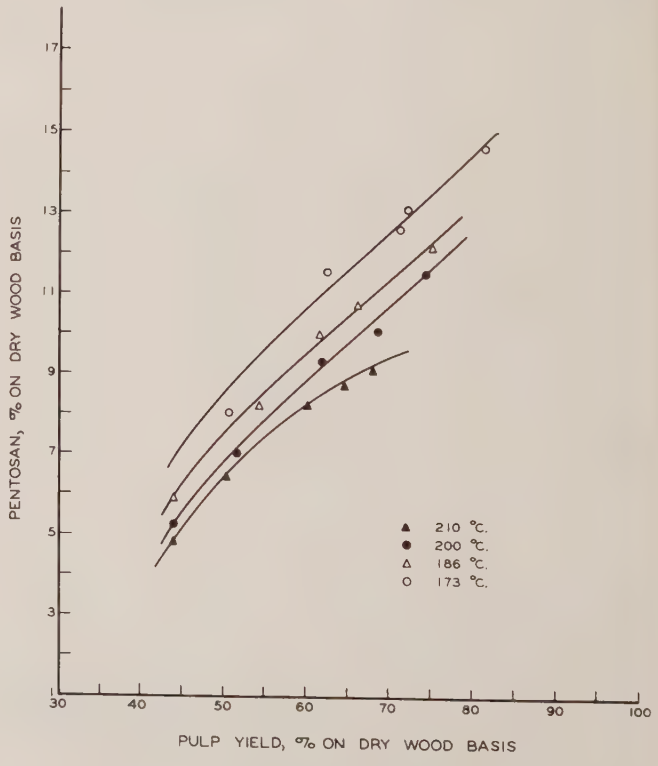

Fig. 7. Pentosan content vs. pulp yield

Table III. Physical Evaluation of Pulps Produced at 186°C.

Cook no. and yield, %	Beating time, min.	Basis weight, g./sq. m.	Caliper, mils	Apparent density g./cc.	Tensile strength, lb./in.[a]	Corrected tensile, lb./in.[b]	Elmendorf tear, factor[c]	Corrected Elmendorf tear[d]	Clark rigidity, factor	Stretch, %[e]	Schopper-Riegler freeness, cc.	B & L opacity, %[f]
Cook 34;	5	65.14	3.8	0.67	24.6	29.8	82.9	100.4	98.2	2.33	830	74.0
yield,	10	65.52	3.5	0.74	29.3	35.5	74.8	90.6	129.7	2.73	800	72.5
75.1	20	65.35	3.2	0.80	34.4	41.7	67.3	81.5	148.8	3.57	670	70.0
	30	65.78	3.1	0.84	37.2	45.1	65.4	79.2	159.0	2.18	585	65.5
	40	64.74	3.0	0.85	38.9	47.1	60.2	72.9	158.7	3.73	430	64.0
Cook 36;	5	66.10	3.6	0.72	36.1	41.2	80.2	91.7	155.8	2.97	850	78.0
yield,	10	64.06	3.3	0.76	40.4	46.1	71.8	82.1	174.1	3.20	820	74.0
66.1	20	65.14	3.2	0.80	39.9	45.5	69.1	79.0	166.4	3.37	745	70.0
	30	65.59	3.0	0.86	44.0	50.2	65.6	75.0	199.7	3.57	590	66.5
	40	65.09	2.8	0.92	44.6	50.9	55.3	63.2	190.1	4.13	345	59.5
Cook 35;	5	65.33	3.4	0.76	35.6	39.1	78.1	85.8	165.2	3.10	835	74.0
yield,	10	65.02	3.2	0.80	40.6	44.6	72.3	79.4	169.8	3.50	790	69.5
61.9	20	65.51	3.0	0.86	44.2	48.6	67.2	73.8	191.7	3.90	665	65.5
	30	64.85	2.9	0.88	44.4	48.8	63.2	69.4	178.4	4.03	480	62.0
	40	67.87	3.0	0.89	45.3	49.8	63.4	69.7	189.3	4.03	390	62.5
Cook 38A;	5	65.15	3.4	0.75	36.1	37.9	92.1	96.6	167.4	3.23	780	77.0
yield,	10	64.55	3.2	0.79	38.4	40.3	85.2	89.4	177.7	3.33	755	74.5
54.3	20	65.55	3.1	0.83	38.4	40.4	82.4	86.5	191.9	3.33	670	71.0
	30	65.30	3.0	0.86	42.4	44.5	75.0	78.7	194.0	3.90	865	69.0
	40	65.19	3.0	0.86	45.1	47.4	79.8	83.8	185.7	3.90	470	67.5
Cook 37;	5	64.28	3.4	0.74	32.1	33.2	73.1	75.7	168.5	2.97	770	78.0
yield,	10	65.09	3.2	0.80	35.7	36.9	67.6	69.9	176.8	3.30	695	76.0
44.0	20	65.17	3.0	0.86	38.5	39.9	59.8	61.9	221.0	3.40	520	72.5
	30	64.20	2.7	0.94	38.1	39.8	49.8	51.5	195.4	3.90	245	66.5
	40	66.13	2.6	1.00	35.9	37.1	42.3	43.8	188.1	3.97	130	59.5

[a] Tensile strength expressed in terms of pounds per inch at a sheet weight of 65.5 g. per sq. m.
[b] Corrected tensile expressed in terms of pounds per inch at a sheet weight of cellulosic material equal to 65.5 g. per sq. m.
[c] Tear factor expressed in grams of force required to tear a sheet of 100 g. per sq. m. basis weight.
[d] Corrected tear expressed in grams of force required to tear a sheet of 110 g. per sq. m. cellulosic weight.
[e] Stretch expressed as percentage elongation of specimen at rupture under tensile strain.
[f] B & L opacity = opacity by contrast ratio—100 $R_0/R_{0.89}$.

1. Decreased the sheet density.
2. Increased the tear factor.
3. Decreased the tensile strength.
4. Increased the opacity.
5. Decreased the stretch values.
6. Decreased zero-span tensile strength.

In all cases the pulping temperature effects observed on the physical tests on handsheets were relatively small and generally amounted to less than a 10% change.

DISCUSSION OF RESULTS

The major effect of increasing pulping temperature was on the rate of pulping. As the cooking temperature increased, the overall pulping reaction rate was *greatly accelerated.* For example, the time required to produce a pulp of 50% yield at 210°C. was only one-fifteenth the time required to pulp to the same yield at 180°C. The common approximation of assuming a doubling in rate for each 10°C. increase in temperature predicts that the elevated temperatures should require one-eighth the pulping time.

Table IV. Physical Evaluation of Pulps Produced at 200°C.

Cook no. and yield, %	Beating time, min.	Basis weight, g./sq. m.	Caliper, mils	Apparent density, g./cc.	Tensile strength, lb./in.[a]	Corrected tensile, lb./in.[b]	Elmendorf tear, factor[c]	Corrected Elmendorf tear[d]	Clark rigidity, factor	Stretch, %[e]	Schopper-Riegler freeness, cc.	B & L opacity, %[f]
Cook 40;	5	65.01	3.8	0.67	25.1	30.5	78.4	95.2	108.2	2.20	835	76.0
yield,	10	65.22	3.6	0.71	28.7	34.9	75.1	91.2	124.7	2.73	805	75.5
74.5	20	65.32	3.4	0.76	33.1	40.2	70.4	85.5	139.8	3.03	690	73.0
	30	67.85	3.4	0.79	35.7	43.4	66.3	80.5	137.8	3.33	565	73.5
	40	67.05	3.1	0.85	37.4	45.4	62.6	76.0	159.8	3.43	350	69.0
Cook 42;	5	65.75	3.6	0.72	33.2	38.8	80.6	94.2	136.5	2.80	840	76.0
yield,	10	66.11	3.4	0.77	38.1	44.5	75.6	88.3	159.0	3.17	800	75.0
68.9	20	65.66	3.2	0.81	38.7	45.2	71.6	83.6	162.7	3.23	740	71.0
	30	65.72	3.0	0.86	39.7	46.4	63.9	74.7	163.8	3.43	490	67.5
	40	64.43	2.9	0.87	40.8	47.7	63.6	74.3	165.1	3.77	310	62.0
Cook 43;	5	65.84	3.5	0.74	36.8	41.2	82.0	91.8	161.3	3.00	830	75.0
yield,	10	65.60	3.3	0.78	38.7	43.4	76.2	85.4	147.3	3.20	810	73.5
61.8	20	65.06	3.1	0.83	40.8	45.7	73.8	82.6	174.3	3.33	670	68.5
	30	65.84	3.1	0.84	41.9	46.9	72.9	81.6	171.5	3.63	610	68.0
	40	65.09	3.0	0.85	44.5	49.8	67.6	75.7	170.2	3.77	415	64.5
Cook 44;	5	63.63	3.5	0.72	30.9	32.3	88.0	92.0	149.9	2.63	790	79.0
yield,	10	63.87	3.3	0.76	34.7	36.3	87.7	91.7	166.0	2.93	740	76.0
51.7	20	64.31	3.2	0.79	37.5	39.2	80.6	84.3	170.7	3.50	660	73.5
	30	65.08	3.2	0.80	38.0	39.7	75.3	78.8	171.2	3.43	555	72.5
	40	64.23	3.0	0.84	40.4	42.2	70.1	73.3	185.3	3.67	420	70.5
Cook 41;	5	65.70	3.5	0.74	25.8	26.5	71.5	73.6	170.0	3.00	760	78.0
yield,	10	64.45	3.2	0.79	33.0	33.9	69.8	71.8	188.0	3.13	715	76.0
44.1	20	63.57	3.0	0.83	35.2	36.3	58.2	60.0	196.4	3.20	535	72.5
	30	64.70	2.9	0.88	35.2	36.3	54.1	55.7	190.2	3.27	320	70.0
	40	64.87	2.7	0.95	39.5	40.7	46.2	47.6	195.5	...	170	64.0

[a] Tensile strength expressed in terms of pounds per inch at a sheet weight of 65.5 g. per sq. m.
[b] Corrected tensile expressed in terms of pounds per inch at a sheet weight of cellulosic material equal to 65.5 g. per sq. m.
[c] Tear factor expressed in grams of force required to tear a sheet of 100 g. per sq. m. basis weight.
[d] Corrected tear expressed in grams of force required to tear a sheet of 110 g. per sq. m. cellulosic weight.
[e] Stretch expressed as percentage elongation of specimen at rupture under tensile strain.
[f] B & L opacity = opacity by contrast ratio—$R_0/R_{0.89}$.

Table V. Physical Evaluation of Pulps Produced at 210°C.

Cook no. and yield, %	Beating time, min.	Basis weight, g./sq. m.	Caliper, mils	Apparent density, g./cc.	Tensile strength, lb./in.[a]	Corrected tensile lb./in.[b]	Elmendorf tear, factor[c]	Corrected Elmendorf tear[d]	Clark rigidity, factor	Stretch, %[e]	Schopper-Riegler freeness, cc.	B & L opacity, %[f]
Cook 47,	5	64.29	3.5	0.72	31.8	37.2	82.4	96.4	148.2	2.60	800	80.0
yield,	10	66.19	3.4	0.77	33.3	39.0	78.6	92.0	156.0	2.83	775	77.5
68.2	20	63.74	3.2	0.78	37.3	43.6	73.7	86.3	159.3	3.23	675	75.5
	30	63.70	3.0	0.84	39.4	46.1	70.6	82.6	173.4	3.40	530	74.5
	40	63.87	2.9	0.87	40.5	47.4	65.8	77.0	182.5	3.40	370	71.5
Cook 46;	5	65.16	3.6	0.71	31.5	35.5	85.9	96.7	145.2	2.67	830	77.5
yield,	10	64.29	3.4	0.74	36.8	41.5	82.4	92.8	154.6	3.23	810	75.0
64.6	20	64.71	3.2	0.80	38.2	43.0	78.8	88.7	164.7	3.50	705	72.0
	30	64.41	3.1	0.82	40.6	45.7	71.4	80.3	162.4	3.90	545	69.5
	40	65.18	3.0	0.86	40.0	45.1	69.0	77.7	182.3	3.70	455	70.5
Cook 49;	5	64.92	3.5	0.73	32.4	36.0	89.3	99.1	160.5	2.57	820	78.5
yield	10	66.04	3.4	0.76	37.5	41.6	83.3	92.5	178.1	3.20	790	76.5
60.1	20	64.79	3.2	0.80	40.4	44.8	75.6	83.9	178.3	3.33	700	73.0
	30	64.60	3.0	0.85	41.0	45.5	71.2	79.0	183.5	3.47	555	70.0
	40	64.65	3.0	0.85	41.2	45.7	68.1	75.5	175.3	3.63	475	70.5
Cook 48;	5	65.01	3.6	0.71	31.4	34.2	86.1	90.9	163.0	2.63	760	80.5
yield,	10	65.47	3.4	0.76	33.1	35.0	82.5	87.1	183.2	2.83	720	78.5
50.3	20	64.43	3.2	0.79	36.9	39.0	72.9	87.1	179.5	3.26	615	75.0
	30	64.73	3.0	0.85	37.4	39.5	74.1	78.2	208.0	3.14	455	73.5
	40	64.44	2.8	0.91	38.9	41.1	59.0	62.4	185.8	3.80	275	70.0
Cook 45;	5	64.55	3.6	0.71	32.0	33.3	68.2	70.9	150.8	2.97	725	80.5
yield	10	64.95	3.3	0.77	34.7	36.0	61.6	64.1	168.2	3.17	645	78.5
43.9	20	64.21	3.1	0.82	35.9	37.3	57.6	59.9	169.8	3.47	410	72.0
	30	64.41	2.8	0.91	35.0	36.4	48.1	50.0	178.7	3.78	170	72.5
	40	64.84	2.6	0.98	32.1	33.4	40.1	41.6	173.0	3.56	110	67.0

[a] Tensile strength expressed in terms of pounds per inch at a sheet weight of 65.5 g. per sq. m.
[b] Corrected tensile expressed in terms of pounds per inch at a sheet weight of cellulosic material equal to 65.5 g. per sq. m.
[c] Tear factor expressed in grams of force required to tear a sheet of 100 g. per sq. m. basis weight.
[d] Corrected tear expressed in grams of force required to tear a sheet of 110 g. per sq. m. cellulosic weight.
[e] Stretch expressed as percentage elongation of specimen at rupture under tensile strain.
[f] B & L opacity = opacity by contrast ratio—$R_0/R_{0.89}$.

With respect to relative rates of removal of cellulose and lignin, it was found that measurements of total lignin, pulp methoxyl content, and holocellulose indicated that increasing pulping temperature decreased the total amount of lignin removed (by about 1% over the temperature range studied) when comparisons were made at equal yields. Increasing pulping temperature did slightly degrade the cellulose fraction, as at equivalent yields high-temperature pulps had a lower pentosan content, decreased viscosity, and a lower alkali-soluble fraction. However, the degradation which did occur was not excessive from a papermaking standpoint. Pulping temperature showed no significant effect on the alkali-resistant portion of the holocellulose fraction and handsheet properties were not greatly affected.

The chemical characterization of the pulps predicted that high-temperature pulps would probably possess slightly lower strength values. This was in accord with the observed handsheet characteristics, as in all cases the pulping temperature effect on sheet properties could be related to decreased intrinsic fiber strength and lower fiber-to-fiber bonding capacity. However, it must be emphasized that, in general, the pulping temperature effect on pulp properties was small.

CONCLUSIONS

1. Increasing pulping temperature greatly accelerated the overall pulping reaction rates of the neutral sulfite process.

2. The pulps produced at high temperatures contained slightly higher percentages of residual lignin and slightly lower percentages of total carbohydrate material than the lower temperature pulps of the same yield. Over a pulping temperature range of 37°C., the increase in residual total lignin amounted to approximately 1.0% at any given yield throughout the yield range.

3. With respect to the chemical characterization of the pulps the following pulping temperature effects were observed.

(a) Increasing pulping temperature decreased the amount of alkali-soluble material remaining in the holocellulose fraction at constant yield.
(b) The percentage of alkali-resistant cellulosic material (on the wood basis) was not affected by pulping temperature, and was only a function of yield.
(c) Increasing the pulping temperature substantially decreased the average degree of polymerization of the holocellulose fraction at a given yield.
(d) Increasing the pulping temperature decreased the amount of pentosans remaining in the holocellulose fraction. Over the 37°C. range investigated, the pentosan content decreased by approximately one-third at a given yield.

4. The temperature effects observed on the physical tests on handsheets were relatively small. When pulps of equivalent yield were compared at the same beating times the direction of changes with increasing pulping temperature were:

(a) Increased tear factor.
(b) Decreased tensile strength.
(c) Increased opacity.
(d) Decreased sheet density.
(e) Decreased stretch.
(f) Decreased zero-span tensile.

5. In all cases, the effect of pulping temperature on sheet characteristics was explainable by considering that high-temperature pulps had a slightly lower fiber strength and lower fiber-to-fiber bonding capacity at the same beating time than did low-temperature pulps.

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Identification of Coniferous Woods

B. FRANCIS KUKACHKA

The identification of coniferous woods is generally regarded as being more difficult than for the hardwood species. This is due to the fact that conifers are more elemental in their structure and, as a consequence, the number of diagnostic features that may be employed is proportionately smaller. Instructions are given here in the sequential use of primary diagnostic features in the identification of coniferous woods. These may be used from the data chart or by sorting marginally perforated cards. Microscopic features are necessarily emphasized because of the greater accuracy obtainable through their usage. The majority of the species described are found in the continental United States and Canada; however, several exotic species found in commercial channels are also included.

EXPERIMENTAL

Equipment

Necessary identification equipment includes: Suitable knives or razor blades, either for freehand or mechanical sectioning; magnifying lens of approximately 15 power; electrical hot plate or equivalent heat source; microscope capable of magnifying up to 400 or more times; a microtome if mechanical sectioning is contemplated; and microscope slides and cover glasses.

Reagents

Required reagents are: 1% solution of caustic soda, and a 50-50 solution of glycerine and 95% ethyl alcohol.

Preparation of Specimens

Because identification may be made from a piece of wood, pulp sample, or a paper sample, two different methods are used in preparing the specimens for examination.

In the case of a piece of wood, it is necessary to examine both radial and tangential sections because most of the diagnostic features will be seen from these surfaces. These sections may be prepared by cutting thin slices freehand with a razor blade or microtome knife. It is usually desirable to wet the surface prior to cutting, or in some cases it may be desirable to boil the block for a short time in order to cut sections that are thin enough to be transparent at the higher magnifications on the microscope. The sections are then placed on a microscope slide, a few drops of the alcohol-glycerine mixture are placed over the sections, and a cover glass applied. The prepared slide is then heated to the boiling point for a minute or two to expel air from the sections. After cooling for a few minutes the slide is ready for examination.

To examine the component cells of a pulp or paper sample, it is usually necessary to boil a small quantity of the sample for a few minutes in a 1% solution of caustic soda to remove sizing materials. The sample is then washed to remove the alkali and shaken vigorously in water to make a suspension of the cells. A few drops of the suspension are placed on a microscope slide and a cover glass is applied. It is usually not necessary to stain the fibers; however, if desired, the staining may be accomplished directly after washing the sample and before or during the shaking process.

DIAGNOSTIC FEATURES USED IN IDENTIFICATION

The present work is based primarily on features visible with a microscope and is intended primarily for wood technologists that have access to an authenticated collection of wood specimens. Detailed descriptions of the various species are not included; however, the presence of diagnostic features is shown in Table I and attention is also called to the supplementary notes on the various genera.

In the following notes, the diagnostic features selected for their value in identification are defined and their significance discussed. The majority of the anatomical features used in this key are also illustrated.

Most of the features refer to microscopic structure; however, there are also included certain general or gross features that are of value in specific instances.

It will be noted that some of the numbered features have been left blank. This was done expressly for those who may wish to enlarge the key by the addition of other species which may, in turn, necessitate the inclusion of more diagnostic features.

1. Resin Canals. When resin canals are present,

B. Francis Kukachka, Forest Products Technologist, Forest Products Laboratory, maintained at Madison, Wis., in cooperation with the University of Wisconsin, Forest Service U. S. Department of Agriculture.

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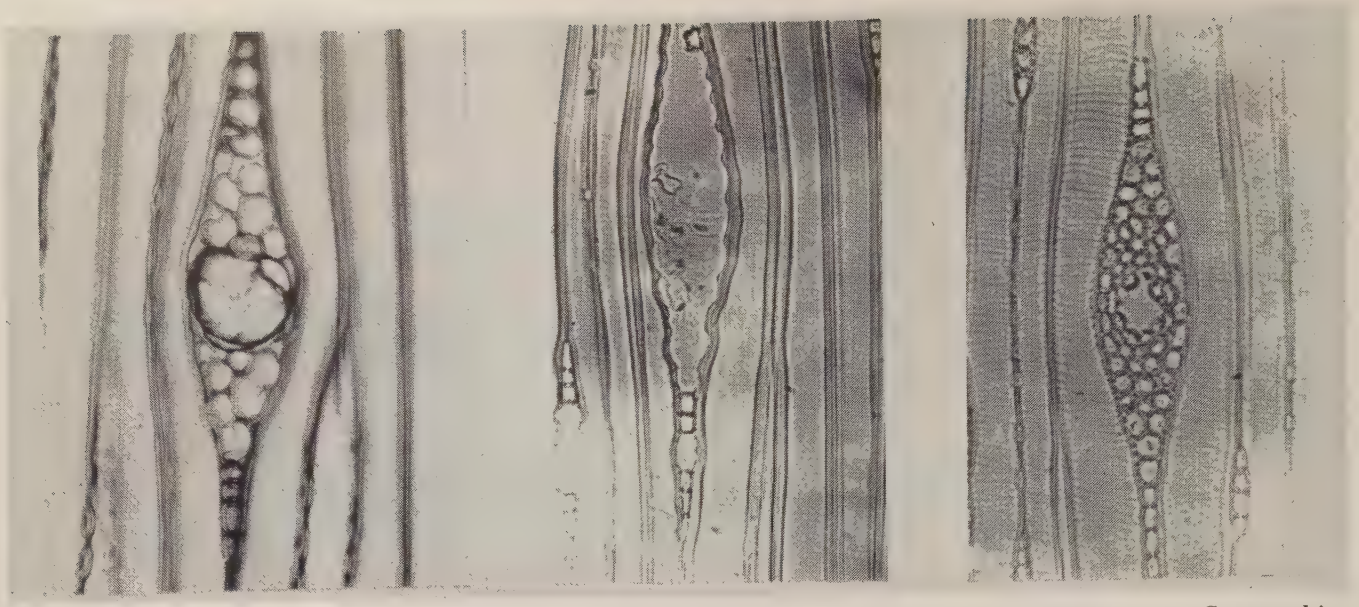


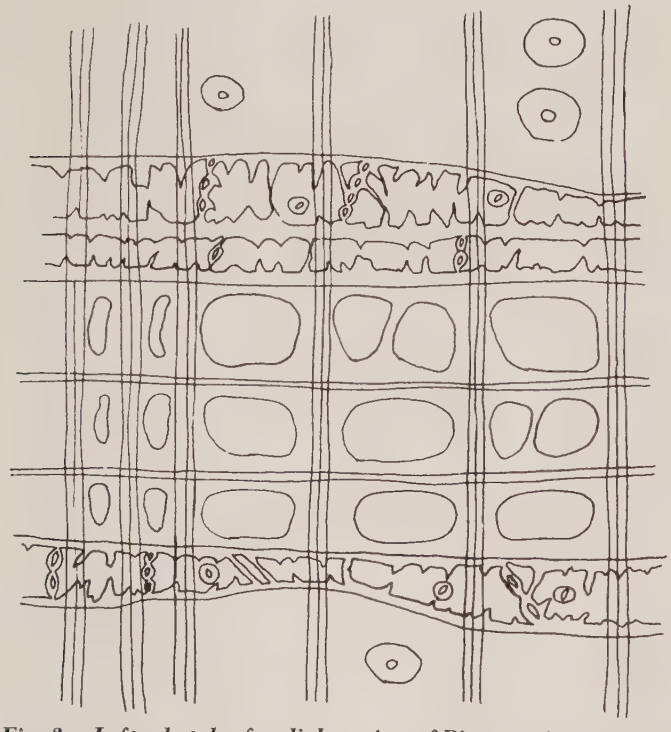
Fig. 1. Left, thin-walled epithelium and ray parenchyma intact after sectioning of embedded specimen. Center, thin-walled epithelium and ray cells torn out in specimen that was not embedded. Right, thick-walled epithelium intact after freehand sectioning of untreated specimen

they occur in both the vertical and horizontal system. On smoothly cut transverse surfaces they appear to be solitary or infrequently paired. Resin ducts vary appreciably in size and abundance and in most species can be detected with the eye. They are largest and most abundant in *Pinus* and of smaller size and fewer in number in *Picea, Larix,* and *Pseudotsuga.* In some instances they appear as short scratch marks on the longitudinal surfaces of the wood or may become more pronounced because of resin stains in adjacent areas. Exudation of resin from the end grain, the presence of pitch pockets, or pitch streaks are additional indicators of the presence of resin canals. The presence of normal ducts can always be verified by an examination of tangential sections under the microscope.

2. Epithelium Cells Thick-walled. In freehand sectioning or sectioning without embedding the wood, species that possess resin canals with thin-walled epithelium cells will show the fusiform wood rays containing the canals to be devoid of an epithelium layer and, in many instances, the adjacent ray parenchyma will also be removed in the process. This condition is shown in Fig. 1 center, where the canal as well as the thin-walled parenchyma cells have been torn out in sectioning without embedding. Figure 1, left, shows a similar-type fusiform ray which had been embedded and all of the cells are intact. Figure 1, right, illustrates the thick-walled type of epithelium which has remained intact even though the section was cut freehand.

3. Blank.

4. Ray Tracheids Common. Ray tracheids may be found in many species if a careful search is made, but their rare occurrence in such cases suffices to distinguish those in which they are immediately seen. In certain genera they may be confined to the margins of the wood rays, as in *Tsuga* and *Larix,* while in others, for instance *Pinus,* they may be both marginal and interspersed. When the ray tracheids are nondentate they may be



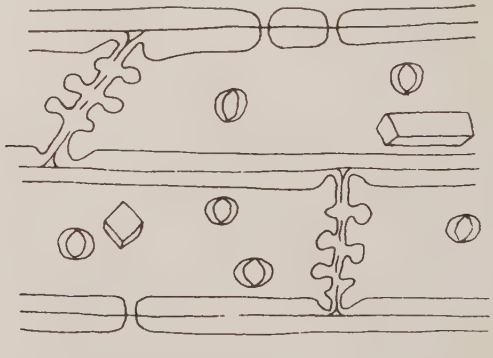


Fig. 2. Left, sketch of radial section of Pinus resinosa *showing two rows of dentate ray tracheids on the upper margin of the wood ray and a single row on the lower margin: the three center tiers of ray parenchyma illustrate 1–2 large, simple, cross-field pitting*

Right, radial section of Abies magnifica *showing nodular end walls of the ray parenchyma cells in pit-like hollows of the horizontal walls. These hollows are referred to as indentures. A solitary crystal appears in each cell*

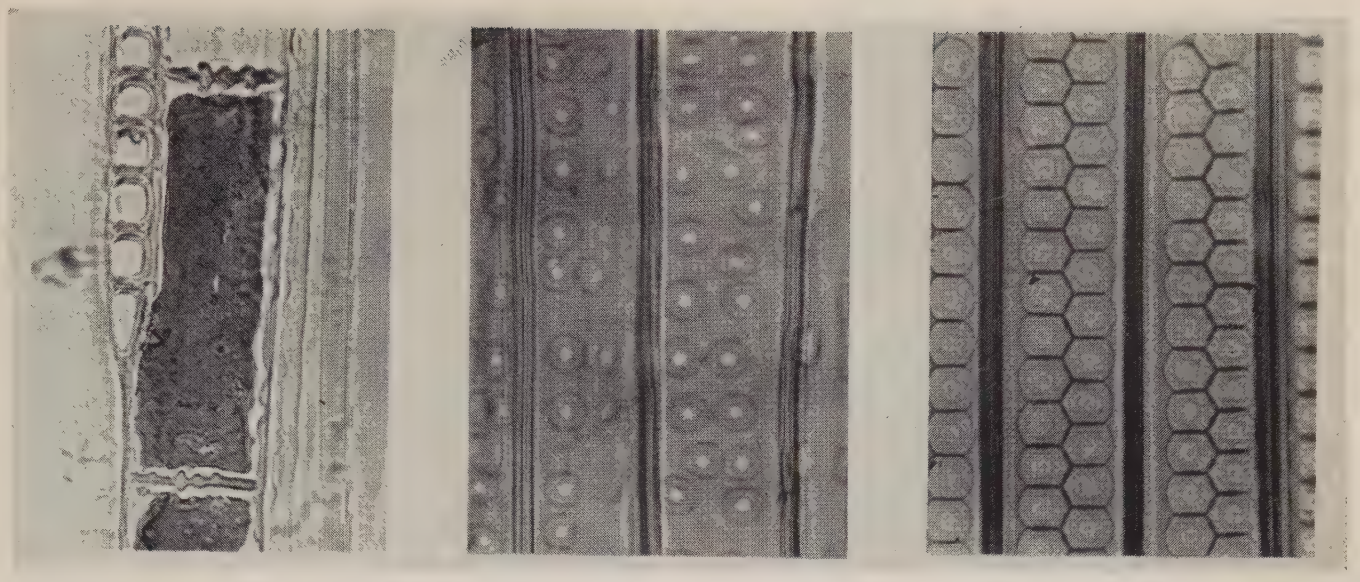


Fig. 3. Left, nodular thickenings of the transverse walls of vertical parenchyma in Taxodium; *Note dark colored contents. Center, bordered pitting of tracheids multiseriate and opposite in* Sequoia. *Right, bordered pitting multiseriate and alternate in* Agathis

differentiated from the ray parenchyma by the presence of small bordered pits in the end walls and will be seen there in sectional view.

5. Ray Tracheids Dentate. Ray tracheids exhibiting toothlike projections of the walls are referred to as dentate (Fig. 2, left), and where they appear fused are known as reticulate. Dentate ray tracheids occur in the genus *Pinus* and are associated with those species which show 1–6 pinoid cross-field pitting. They may also occur in combination with 1–2 large, cross-field pitting as in *Pinus resinosa* and *Pinus sylvestris.*

Minute denticulations are regularly present in *Picea* and sporadic in *Larix.* These should be observed from radial sections in the latewood or summerwood portions of the growth rings.

6. Indenture. Depressions at the corners of the ray cells, as observed from radial sections, are referred to as indentures. They appear as very small, pitlike hollows in the horizontal walls in which the ends of the vertical walls stand (Fig. 2, right). These should be observed at a magnification of about 400 times, and used as an identification feature only if they are definitely present. Of our native species, this feature is of greatest diagnostic value in the cedar species.

7. End Walls of Ray Parenchyma Nodular. Beadlike thickenings are sometimes present on the vertical walls of the ray parenchyma cells and can be observed from radial sections. Similar thickenings may occur on the transverse walls of the vertical parenchyma cells (Fig. 2, right).

8. Crystals Present. Crystals appearing in the form of regular prisms, cubes, or octahedra are of common occurrence in one group of the genus *Abies,* and occur sporadically in *Picea sitchensis* and *Libocedrus decurrens.* The crystals are generally confined to the ray parenchyma cells although they may also be found in the vertical parenchyma in *Abies.* Figure 2, right, illustrates two of the crystal shapes that may occur in *Abies.*

9. Blank.

Cross-field Pitting. The pits occurring on the areas of contact between the ray parenchyma cells and the adjacent vertical tracheids are referred to as cross-field pitting. This may vary from a single large pit that occupies most of the area of the cross-field, as in the case of the white pines, to very small pits that occupy only a small portion of the cross-field areas, as in the case of the spruces. Because the number of pits per cross-field as well as their shape will vary within a given growth ring, it is necessary to limit observations of this feature to the first two or three rows of earlywood or springwood tracheids.

10. Cross-field Pitting, 1–6 Pinoid. Pitting of the 1–6 pinoid type may be without a border or show narrow borders. The individual pits are irregular or variable in shape and size and there may be one to six pits per cross-field. Pitting of this type is limited to the genus *Pinus* and is associated with dentate ray tracheids.

11. Cross-field Pitting, 1–2 (4) Large, Simple. Within this category of 1–2 (4) pits that are large, simple, or nearly so are included the large windowlike pits of the white pines, red pine, and the uniformly oval and more numerous pits of sugar pine (Fig. 2, left). In the case of the white pine and red pine there may be one or two pits per cross-field, whereas in sugar pine there may be two to four pits per cross-field.

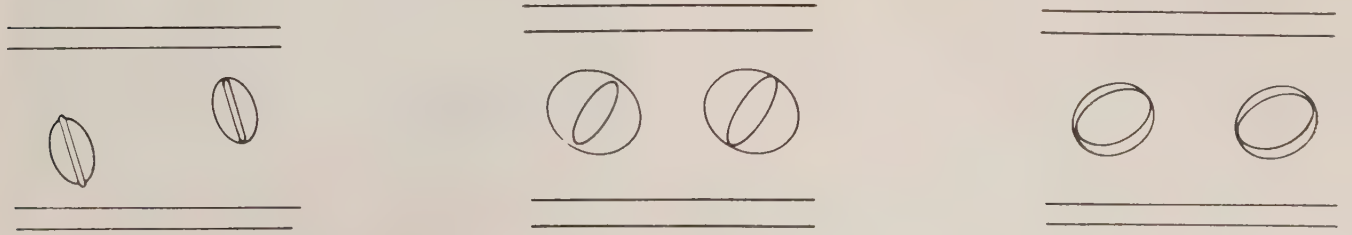


Fig. 4. Cross-field pitting: piceoid (left), cupressoid (center), and taxodioid (right)

12. Cross-field Pitting, Piceoid. Piceoid pits show a narrow and often slightly extended aperture. The aperture in this instance is distinctly narrower than the distance from the aperture to the border (Fig. 4, left).

13. Cross-field Pitting, Cupressoid. Cupressoid pits are those in which the aperture is ovoid and included. The aperture is slightly narrower than or as wide as the space on either side between the aperture and the border (Fig. 4, center).

14. Cross-field Pitting, Taxodioid. Taxodioid pits have a large, ovoid-to-circular included aperture that is wider than the space on either side between the aperture and the border (Fig. 4, right).

15. Blank.

16. Blank.

17. Blank.

18. Bordered Pitting of Tracheids Multiseriate and Opposite. This feature of pitting of tracheids biseriate or triseriate and opposite applies to the common occurrence of 2–4 bordered pits throughout the length of the tracheids and not to occasional groups that may occur at the overlapping portions of the tracheids. This feature is most pronounced in *Sequoia* and *Taxodium* and of infrequent occurrence in other genera; see Fig. 3, center.

19. Bordered Pitting of Tracheids Multiseriate and Alternate. Tracheid pitting may be 2–4 seriate in this group but in alternate arrangement. This feature separates *Araucaria* and *Agathis* from all other conifers; see Fig. 3, right.

20. Spiral Thickenings in Tracheids. Spiral thickenings of tracheids occur only in *Pseudotsuga, Taxus,* and *Torreya.* In *Torreya* the thickenings tend to occur in pairs which helps to separate this genus anatomically from *Taxus.* Spiral thickenings should not be confused with the spiral checks that characterize compression wood. Figure 1, right, illustrates spiral thickenings in *Pseudotsuga.*

21. Blank.

22. Vertical Parenchyma Present. When present, parenchyma cells are usually detected without difficulty because of their dark contents. The cells may be limited to the growth ring boundary as in *Abies* and *Tsuga* or may be interspersed throughout the growth ring as in *Taxodium* and *Juniperus.* The dark contents of vertical parenchyma are shown in Fig. 3, left.

23. Transverse Walls of Vertical Parenchyma Nodular. Beadlike thickenings on the transverse walls of vertical parenchyma, similar to those that may occur on the end walls of the ray parenchyma cells, are best observed from tangential sections. The presence of these thickenings and their relative size are very helpful in differentiating between certain species. *Sequoia* and *Taxodium* are readily separated anatomically on this basis; see Fig. 3, left.

24. Blank.

25. Blank.

26. Heartwood Colored. This characteristic is used only with those species that possess a strongly colored heartwood, not where the heartwood exhibits only a slightly darker color than the sapwood. This feature is to be used in the positive sense only.

27. Distinctive Odor. Distinctive odors will range from the rank odor of *Abies lasiocarpa* to the sweetly aromatic odors found in *Thuja plicata* and *Libocedrus decurrens.* Faint odors may be accentuated by moistening a freshly exposed heartwood surface or by heating a moistened surface. This characteristic is to be used only in the positive sense and to best advantage in those woods in which resin canals are absent.

28. Greasy Feel. A characteristic greasy feel is found in *Taxodium* and in some specimens of *Pinus ponderosa.* This feature is to be used only in the positive sense.

29. Dimpled Grain. Dimpled grain is due to the indentations of the cambium produced by resin cysts in the bark. Thin-barked species such as *Pinus contorta* show this feature prominently on flatsawn surfaces. Dimples also occur frequently in *Pinus ponderosa, Picea sitchensis,* and sporadically in several other species.

30. Transition Abrupt. Abrupt transition refers to the sharp definition of the springwood and summerwood of the same growth ring. Figure 5, left, illustrates the abrupt transition in *Larix* and Fig. 5, right, shows the gradual transition of *Pinus strobus.* Species that regularly show an abrupt transition may show a gradual transition in wide growth rings, hence this feature should be used only in the positive sense.

31. Blank.

Geographic Origin

32. Exotic. Species originating outside the boundaries of the continental United States and Canada are known as exotic.

33. Eastern United States. Species whose natural range is east of the Great Plains are listed as from the eastern United States.

34. Western United States. Species whose natural range is west of the Great Plains are classified as from the western United States.

USE OF DATA TABLE AND CARD KEY IN IDENTIFICATION

The data in Table I may be used independently as a key or the data may be transposed to cards and the identification may be accomplished by sorting. The suggested layout of the card key is shown in Fig. 6.

Use of Tabulated Data as a Key

The plus marks in Table I represent the presence of

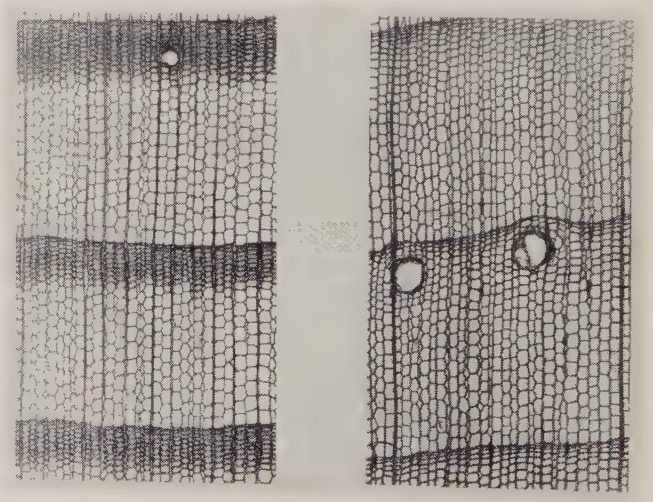


Fig. 5. Left, abrupt transition in* Larix *and one small vertical resin canal in the summerwood. Right, gradual transition in* Pinus strobus *and two large vertical resin canals at the margin of the summerwood

Table I. Identification Chart and Data for Preparation of Card Keys

Diagnostic features	Feature number	Pseudotsuga	Larix laricina	Larix occidentalis	Picea sitchensis	Picea spp.	Picea spp.	Pinus spp.	Pinus spp.	Pinus resinosa	Pinus strobus	Pinus monticola-lambertiana	Pinus spp. (*foxtail*)	Pinus spp. (*pinyon*)	Chamaecyparis nootkatensis	Tsuga heterophylla	Tsuga canadensis	Abies balsamea	Abies spp. (*white firs*)	Abies lasiocarpa	Juniperus spp.	Juniperus spp.	Fitzroya cupressoides	Libocedrus decurrens	Cupressus arizonica	Taxus brevifolia	Torreya taxifolia	Thuja plicata	Thuja occidentalis	Cupressus lusitanica	Chamaecyparis lawsoniana	Chamaecyparis thyoides	Taxodium distichum	Sequoia sempervirens	Araucaria-Agathis
		Resin canals present													*Resin canals absent*																				
		Epithelium thick-walled						*Epithelium thin-walled*							*Ray tracheids present*			*Ray tracheids absent* — *End walls of ray cells nodular*								*End walls of ray cells smooth*									
Canals																																		
Present	1	+	+	+	+	+	+	+	+	+	+	+	+	+																				
Epithelium thick-walled	2	+	+	+	+	+	+																											
	3																																	
Rays																																		
Tracheids present	4	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+																	
Tracheids dentate	5							+	+	+																								
Indenture	6	+	+	+	+	+	+									+	+	+	+	+	+	+		+			+	+						
End walls nodular	7	+	+	+	+	+	+				+	+	+	+	+	+	+	+	+	+	+	+	+	+	+									
Crystals	8																		+															
	9																																	
Cross-field pitting																																		
1-6 pinoid	10							+	+																									
1–2 (4) large	11									+	+	+																						
Piceoid	12	+	+	+	+	+	+						+	+		+	+																	
Cupressoid	13														+						+	+	+	+	+	+	+			+	+	+	+		+
Taxodioid	14																	+	+	+								+	+				+	+	
	15																																		
	16																																		
	17																																		
Tracheids																																		
Pits 2–4 opposite	18		+	+	+												+															+	+	
Pits 2–4 alternate	19																																	
Spirals	20	+																								+	+							+
	21																																		
Vertical parenchyma																																		
Present	22	+													+	+	+	+	+	+	+	+		+	+			+	+	+	+	+	+	+	
Transverse walls nodular	23	+													+	+	+	+	+	+	+	+	+	+	+			+	+	+	+		+		
	24																																		
	25																																		
General																																		
Heartwood	26	+	+	+	+			+	+	+	+	+	+								+	+	+	+		+		+	+	+		+	+	
Odor	27	+													+					+	+	+		+	+		+	+	+	+	+	+			
Greasy	28																															+			
Dimpled	29																																		
Transition abrupt	30	+	+	+				+	+	+							+						+					+	+			+	+	
	31																																		
Origin																																		
Exotic	32																						+							+				+
Eastern	33		+			+		+		+	+						+	+			+								+		+	+	+	
Western	34	+		+	+		+		+			+	+	+	+	+			+	+		+		+	+	+	+	+			+			

the given characteristic for a particular species or group of species. Blank spaces indicate the absence of the feature. The data are so tabulated that the species and groups are reduced to a small number within each category, which permits easier comparisons leading to identification. Under the heading "Resin canals present" and the subheading "Epithelium thin-walled" we find all the pines. Further separation may be accomplished by means of the presence or absence of dentate ray tracheids and still further by means of the cross-field pitting. This elimination may be continued until the identification is pinpointed to a single group.

In transposing the data from Table I to marginally perforated cards, the features marked with a plus (+) are to be indicated on the card by a notch. Features which are shown as blanks in the table remain unnotched on the card. For example, perforation no. 1 is designated as "Resin canals present" and, if notched, indicates the presence of this feature; if left unnotched, this indicates the absence of resin canals. Upon inserting a needle or thin rod into a pack of cards, those which are notched at a particular perforation will fall from the pack when the entire series is lifted and gently shaken. This process is repeated for a succession of the more important characters of the sample until a single card falls from the pack and the determination is accomplished.

When the region of growth is positively known, it is usually desirable to start sorting at this point; in so doing the card pack will be reduced by about one half and permit more accurate diagnosis.

Preferred sequence of operation for woods with resin canals:

Region of growth if positively known.
Resin canals present or absent—cards falling from pack are those woods in which canals are present.
Sort for thick-walled epithelium—cards falling from pack are woods with thick-walled epithelium and those remaining on needle are those with thin-walled epithelium.
If epithelium is thin-walled, then sort for ray tracheids dentate—those falling from the pack have dentate ray tracheids and those remaining on the needle have smooth or non-dentate ray tracheids.
Next sorting should be in cross-field pitting, followed by any other feature which is presented by the particular sample.

Preferred sequence of operation for woods without resin canals:

Region of growth if positively known.
Resin canals present—the cards remaining on the needle are the woods without resin canals.
Ray tracheids common—cards falling from pack are those in which ray tracheids are common and those remaining on needle are without ray tracheids.
End walls of ray cells nodular—cards falling from pack contain this feature and cards remaining on needle are those woods in which the end walls are smooth.
Continue with type of cross-field pitting, vertical parenchyma present, vertical parenchyma if present with or without nodular transverse walls, bordered pitting 2–4 seriate and whether alternate or opposite, indenture, followed by any other feature pertinent to the specimen.

Species having highly distinctive characteristics can be sorted very quickly without going through the above operations. Douglas-fir, for example, can be arrived at in two sorts, the first for spiral thickenings present in the vertical tracheids and the second for resin canals present. The red pines can likewise be removed

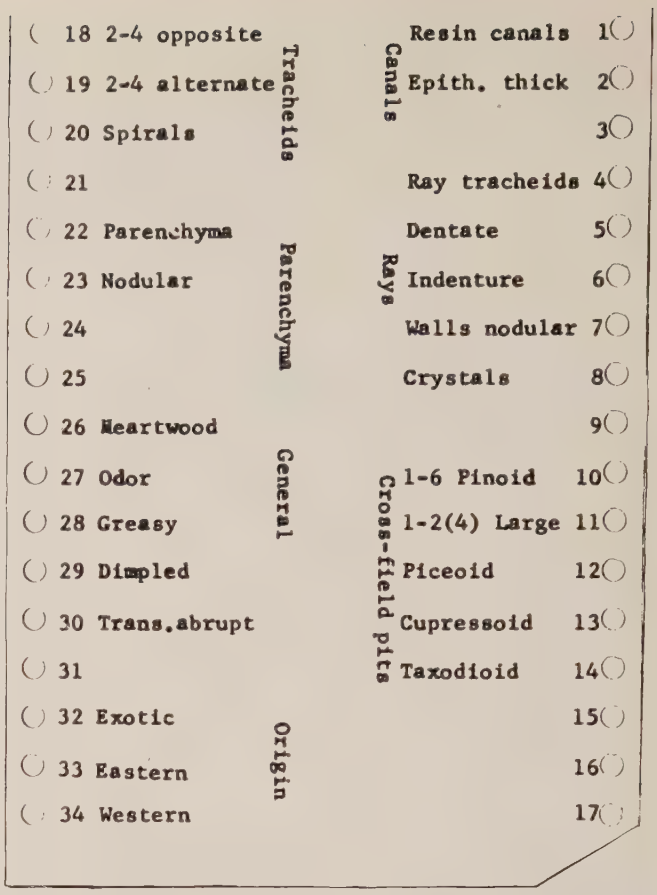


Fig. 6. Suggested layout of features for card sorting key

in two sorts—for ray tracheids dentate, and cross-field pitting 1–2 (4) large. A single sort at tracheid pitting multiseriate and alternate will immediately bring out the Araucariaceae (*Agathis* and *Araucaria*).

SUPPLEMENTARY NOTES

Summarized here are the important anatomical features of the various genera of conifers contained in the key and supplementing the data in Table I. Means of distinguishing the individual species are given here because such specific identifications often depend on characteristics that are insufficiently precise for inclusion in the list of key features. The distinctive features of each genus and the degree to which the genus may be subdivided in anatomical or other features are also noted.

Abies

Nine species of *Abies* are native to the United States and Canada. The only eastern species of commercial importance is balsam fir (*A. balsamea* (L.) Mill.). The other eastern species, Fraser fir (*A. fraseri* (Pursh.) Poir.) is extremely limited in its distribution and hence of little importance. The western species, Pacific silver fir (*A. amabilis* (Dougl.) Forbes), white fir (*A. concolor* (Gord. & Glend.) Lindl.), grand fir (*A. grandis* (Dougl.) Lindl.), subalpine fir (*A. lasiocarpa* (Hook.) Nutt.), California red fir (*A. magnifica* A. Murr.), and noble fir (*A. procera* Rehd.) are of considerable importance from the production standpoint. The bristlecone fir (*A. bracteata* D. Don) is limited to Monterey County, Calif., and does not enter commercial channels. The latter species may be readily recognized by the very frequent occurrence of traumatic resin canals.

Woods belonging to this genus may be readily recognized anatomically by the following combination of features: Resin canals lacking, ray tracheids lacking, end walls of ray parenchyma nodular, and cross-field pitting taxodioid.

The woods of this genus may be further subdivided into two groups on the basis of the color of the ray cell contents. In the eastern species and in subalpine fir the ray cell contents are colorless or at most a very pale yellowish color, and frequently tend to form a reticulum within the cells so that detection of the end walls may be somewhat difficult. These three species are further characterized by the lack of crystals in the ray parenchyma. The wood of *Abies lasiocarpa* frequently has a rather foul odor and the knots are distinctly yellowish in color.

The remaining species, all western, have ray cell contents that are distinctly reddish brown. Crystals may be found in all species of this series but are common to abundant in *A. magnifica* and *A. concolor*, and sparse or infrequent in *A. amabilis*, *procera*, and *grandis*. For practical considerations, the western species are classed collectively as "white fir."

Araucariaceae

In the *Araucariaceae* family are three species that enter commercial channels: Brazilian araucaria or "Parana pine" (*Araucaria angustifolia* (Bert.) O. Ktze.) of Brazil; klinki pine (*Araucaria klinkii* Lauterb.) of Borneo; and almaciga or "sakar" (*Agathis philippinensis* Warb.) of the Philippine Islands. The group as a whole is easily separated from all other coniferous woods by the 2–4 seriate bordered pitting of the vertical tracheids which is in alternate arrangement (Fig. 5, right). The two *Araucarias* are separated from *Agathis* by the presence of leaf traces in the *Araucarias*. These traces appear as tiny pin knots arranged obliquely as seen on the surface of flatsawn boards. Brazilian araucaria tends to be yellowish in color and frequently shows reddish or pinkish streaks while klinki pine is pinkish in color, is lighter in weight, and does not show reddish streaks. In color and luster, klinki pine is very similar to Sitka spruce (*Picea sitchensis* (Bond.) Carr.).

The lack of growth rings in the family also helps to separate these imported woods from native softwood species.

Chamaecyparis

Three species of *Chamaecyparis* occur within the United States and Canada: Atlantic white-cedar (*C. thyoides* (L.) B.S.P.), of the coastal plain from southern Maine to Mississippi; Port-Orford-cedar (*C. lawsoniana* (A. Murr.) Parl.) of southwestern Oregon and northwestern California; and Alaska-cedar (*C. nootkatensis* (D. Don) Spach), which ranges from southeastern Alaska to northwestern California.

The three species vary appreciably and possess no features in common that would distinguish the genus. The heartwood of *C. nootkatensis* is yellowish and that of *C. lawsoniana* ranges from yellowish-white to a pinkish-brown or very pale brown. In both species there is no sharp contrast in color between heartwood and sapwood. The heartwood of *C. thyoides* is a light brown with a pinkish or reddish cast and is sharply demarcated from the sapwood.

From the standpoint of odor the three species differ rather markedly. The heartwood of *C. thyoides* is aromatic and resembles that of northern white-cedar (*Thuja occidentalis L.*); the heartwood of *C. lawsoniana* is strongly aromatic with a pungent, gingerlike odor; and the heartwood of *C. nootkatensis* has an odor that resembles that of raw potatoes.

Anatomically they may be separated as follows: *C. nootkatensis* has ray tracheids that are quite large and frequently comprise the entire wood ray; the end walls of the vertical parenchyma are nodular, as are also the end walls of the ray parenchyma cells; and indenture is present. *C. lawsoniana* and *C. thyoides* are similar in that they lack ray tracheids and the end walls of the ray cells are smooth and without indenture. They differ in that the transverse walls of the vertical parenchyma are nodular in *C. lawsoniana* and smooth in *C. thyoides*.

Cupressus

Of the various species of *Cupressus*, only two are occasionally encountered: Arizona cypress (*C. arizonica* Greene) of the southwestern United States and Bentham cypress (*C. lusitanica* Miller) of Mexico and Guatemala. The heartwood of *C. arizonica* is not differentiated from the sapwood, is yellowish in color and aromatic. The heartwood of *C. lusitanica* is a pale reddish brown in color and is distinctly separated from the light-colored sapwood. The heartwood of *C. lusitanica* is also aromatic.

Anatomically *C. arizonica* has many of the features common to Juniperus; however, *C. arizonica* tends to have lower rays and the end walls of the ray parenchyma cells are not as conspicuously nodular as in *Juniperus*. When heartwood is present, the two genera can be readily separated.

C. lusitanica differs from *C. arizonica* in that the end walls of the ray cells are not nodular in *C. lusitanica* and indenture is lacking or obscure.

Fitzroya

The single species of *Fitzroya*, alerce (*F. cupressoides* (Mol.) Johnston) is native to southern Chile. Superficially the wood resembles that of redwood (*Sequoia sempervirens* (D. Don) Endl.) but may be differentiated when split radial faces of the two species are compared. In redwood the rays are two to three times higher than those of alerce. Anatomically, alerce may be separated from redwood by the presence of indenture, the end walls of the ray cells are nodular, cupressoid pitting is present, and the wood rays are usually under 12 cells in height.

Juniperus

The heartwood of the various species of *Juniperus* is readily distinguishable from all other conifers by its distinctive odor that is generally classified as "cedar-chest" or "pencil" odor. On the basis of heartwood color, two groups may be differentiated: (1) those with a deep-red or purplish-red color as in eastern redcedar (*J. virginiana L.*), southern redcedar (*J. silicicola* (Small) Bailey), and Rocky Mountain juniper (*J. scopulorum* Sarg.) and (2) those with a brownish-colored heartwood that includes all of the western species except *J. scopulorum*.

Anatomically, *Juniperus* may be distinguished from other woods with a highly colored and aromatic heartwood by its abundant vertical parenchyma with nodular transverse walls, ray parenchyma with abundantly nodular ends walls, indenture, dark-colored ray cell contents, and intercellular spaces between the vertical tracheids.

Larix

Three species of *Larix* occur in the United States and Canada: Tamarack (*L. laricina* (Du Roi) K. Koch) of the northeastern United States and from southeastern Canada to the Yukon; western larch (*L. occidentalis* Nutt.) of the northwestern United States and southeastern British Columbia; and subalpine larch (*L. lyallii* Parl.), which is a high-elevation species having the same range as *L. occidentalis* but not of commercial importance.

On the basis of anatomical structure, *Larix* is readily separated from other genera that have resin canals with thick-walled epithelium cells. This separation is made on the basis of the abrupt transition from earlywood to latewood and the bordered pitting of the vertical tracheids, which is frequently biseriate. Western larch may be separated from tamarack using the following combination of features: Heartwood of *L. occidentalis* is russet brown, whereas in *L. laricina* it is a yellowish brown; latewood is generally wider and more pronounced in *L. laricina* than in *L. occidentalis;* growth rings are generally more uniform in *L. occidentalis* than in *L. laricina* and bordered pitting is more commonly biseriate in *L. occidentalis* than in *L. laricina.* The locality of growth affords a very reliable means of separation of these two species.

Libocedrus

The single American species of *Libocedrus,* incense-cedar (*L. decurrens* Torr.), occurs from western Oregon to southern California.

The heartwood is reddish brown to dull brown and sometimes has a purplish cast. The odor of the heartwood is distinctly aromatic and rather similar to that of western redcedar (*Thuja plicata* Donn). Anatomically, it may be distinguished from other genera that have nodular thickenings on both the end walls of the ray cells and the transverse walls of the vertical parenchyma since *Libocedrus* lacks indenture which is present in the other genera.

Picea

Seven species of *Picea* occur in the United States and Canada, although only five are of commercial importance. The most important species are white spruce (*P. glauca* (Moench) Voss) and black spruce (*P. mariana* (Mill.) B.S.P.), which range from the northeastern United States across Canada to Alaska; red spruce (*Picea rubens Sarg.*) which ranges from the Middle Atlantic States to Nova Scotia: Engelmann spruce (*P. engelmanii* Parry) of the Rocky Mountain region; and Sitka spruce (*P. sitchensis* (Bong.) Carr.), which ranges from southern Alaska to northeastern California. Brewer spruce (*P. breweriana* S. Wats.) of southwestern Oregon and northern California and blue spruce (*P. pungens* Engelm.) of the Rocky Mountain region do not enter commercial markets.

The heartwood of *P. sitchensis* is pinkish in color and is sharply demarcated from the white sapwood. The heartwood of the other species is light colored and there is no difference between heartwood and sapwood. Anatomically *P. sitchensis* can be separated from the other species on the basis of the abundant yellowish-brown deposits in the ray cells and the frequent occurrence of biseriate bordered pitting of the vertical tracheids. The other species only show occasional pale yellowish-colored deposits and the tracheid pitting is uniseriate. *P. sitchensis* occasionally has crystals in the ray cells, which is a further aid in separating this wood from the other spruces. Split tangential faces of *P. sitchensis* commonly show dimpled grain. Separation of the other species is not practical except in some instances where the geographical source is known.

Anatomically, *Larix* and *Picea* are very similar; however, separation may be accomplished by the abrupt transition from earlywood to latewood in *Larix* and gradual in *Picea,* and by the presence of minute denticulations on the walls of the ray tracheids in *Picea* but rare in *Larix.*

Pinus

The members of the genus *Pinus* are readily separated from all other conifers by their resin canals, which have thin-walled epithelium cells. Specific identification is generally not possible, however, the genus can be subdivided into five groups on the basis of the ray tracheids and the type of cross-field pitting.

- Ray tracheids nondentate.
  - Cross-field pitting 1–2 large, simple or nearly so
    - Eastern white pine (*P. strobus* L.)
    - Western white pine (*P. monticola* Dougl.)
    - Included here are the stone pines of small economic importance which are: whitebark pine (*P. albicaulis* Engelm.) and limber pine (*P. flexilis* James).
  - Cross-field pitting 2–4 ovoid.
    - Sugar pine (*P. lambertiana* Dougl.)
  - Cross-field pitting piceoid.
    - Species of little importance and comprising two groups:
    - Foxtail pines: bristlecone pine (*P. aristata* Engelm.) and foxtail pine (*P. balfouriana* Grev. & Balf.)
    - Pinyon pines: Mexican pinyon (*P. cembroides* Zucc.); pinyon (*P. edulis* Engelm.); singleleaf pinyon (*P. monophylla* Torr. & Frem.); and Parry pinyon (*P. quadrifolia* Parl.)
- Ray tracheids dentate to reticulate.
  - Cross-field pitting 1–2 large, simple or nearly so.
    - Red pine (*P. resinosa* Ait.) and the European Scotch pine (*P. sylvestris* L.)
  - Cross-field pitting 1–6 pinoid.
    - Western species, principally ponderosa pine (*P. ponderosa* Laws.) Jeffrey pine (*P. jeffreyi* Grev. & Balf.), and lodgepole pine (*P. contorta* Dougl.)
  - Eastern and southern species, principally jack pine (*P. banksiana* Lamb.); slash pine (*P. elliottii* Engelm.); longleaf pine (*P. palustris* Mill.); shortleaf pine (*P. echinata* Mill.) and loblolly pine (*P. taeda* L.).

In this group characterized by 1–6 pinoid pitting, separation of the eastern and western species may generally be made by the more prominent latewood found in the eastern species and particularly in the more important southern species. *P. elliottii* and *P. palustris* frequently show multiple latewood bands within individual growth rings which aids in separating these two species from all the others. *P. palustris* can also be separated from the other eastern and southern species when pith is present in the specimen. In this species

the pith is commonly 0.2 in. in diameter while in the other species it is 0.1 in. in diameter or smaller.

Dimpled grain is distinctive of *P. contorta* and occurs rather frequently in *P. ponderosa*. In the latter species, however, the dimples are larger and fewer per unit area than those of *P. contorta*.

Pseudotsuga

The Douglas-fir of commerce is the produce of *Pseudotsuga menziesii* (Mirb.) Franco, occurring from southwestern British Columbia southward through California, and *P. menziesii* var. glauca (Beissn.) Franco, which is native to the Rocky Mountain region.

Another species, bigcone Douglas-fir (*P. macrocarpa* (Vasey) Mayr) is limited to the mountains of southern California and is not commercially important.

Pseudotsuga is readily distinguished from all other native conifers by the combination of resin canals present and the occurrence of spiral thickenings of the vertical tracheids.

The heartwood of Douglas-fir is reddish or pinkish and occasionally may have a russet-brown color. The odor of the heartwood is highly distinctive for this species but difficult to describe.

Sequoia

Only one species of *Sequoia*, Redwood (*S. sempervirens* (D. Don) Engl.), is of commercial importance. The other species, giant sequoia (*S. gigantea* (Lindl.) Decne.), occurs in protected groves. Both species are native to California.

The light red to deep reddish-brown heartwood readily separates redwood from other conifers with colored heartwood. The wood is without odor.

Anatomically, it is identified by its biseriate or triseriate bordered pitting, end walls of ray cells without nodular thickenings, taxodioid cross-field pitting, and relatively inconspicuous nodular thickenings on the transverse walls of the vertical parenchyma. Anatomically it is very similar to *Taxodium* which differs from *Sequoia* in that the transverse walls of the vertical parenchyma are conspicuously nodular. (See *Fitzroya* for difference between that genus and *Sequoia*.)

Taxodium

Baldcypress (*Taxodium distichum* (L.) Rich.) and the variety *nutans* (Ait.) Sweet supply the cypress of commerce. *T. distichum* occurs in the coastal plain from southern Delaware to southeastern Texas and in the Mississippi River valley as far north as Missouri and southern Illinois. The variety *nutans* occurs in the coastal plain from southeastern Virginia to southeastern Louisiana.

The heartwood of *Taxodium* is quite variable in color and ranges from yellowish to dark brown, reddish brown, or almost black. The heartwood is further characterized by its greasy or oily feel and often by a rancid odor.

Anatomically it is very similar to *Sequoia* but has more conspicuous nodular thickenings on the transverse walls of the vertical parenchyma. The cross-field pitting of *Taxodium* may be taxodioid or cupressoid.

Taxus

Two species of *Taxus*, Florida yew (*T. floridana* Nutt.) and Pacific yew (*T. brevifolia* Nutt.), are native to the continental United States; however, only the Pacific yew enters the market. *T. floridana* is rare and local in Gadsden and Liberty Counties of northwestern Florida. *T. brevifolia* occurs from southeastern Alaska to northern California and in the northern Rocky Mountain region.

The heartwood ranges in color from bright orange to russet brown and is without odor. Anatomically it can be separated from all other American conifers except *Torreya* by its spiral thickenings in the vertical tracheids and lack or resin canals. In *Taxus* the cross-field pits are 8 to 10 μ in diameter while in *Torreya* they are about 6 μ in diameter (see *Torreya*).

Thuja

Two species of *Thuja* occur in the United States and Canada. Northern white-cedar (*T. occidentalis L.*) is found in southeastern Canada and northeastern United States to the Lake States region, while Western redcedar (*T. plicata* Donn) ranges from southeastern Alaska to northwestern California and also in the northern Rocky Mountain region.

The heartwood of *T. occidentalis* is a pale brown with a faint but characteristic cedary odor; the heartwood of *T. plicata* is reddish or pinkish brown to dull brown with a much stronger and spicy aromatic odor.

Anatomically the genus is defined by taxodioid cross-field pitting, end walls of ray cells smooth, indentures distinct, transverse walls of vertical parenchyma nodular. *T. occidentalis* may be separated anatomically from *T. plicata* by the more frequent biseriate bordered pitting and the more abundant parenchyma of *T. plicata*. The end walls of the ray cells may occasionally show nodular thickening, particularly near the growth ring boundaries. In *T. occidentalis* the ray cell contents appear reticulate and tend to obscure the end walls, while in *T. plicata* the contents of the ray cells are more uniformly distributed and do not obscure the end walls.

Torreya

The genus *Torreya* consists of two rather rare species: Florida torreya (*T. taxifolia* Arn.) of southwestern Georgia and northwestern Florida and California torreya (*T. californica* Torr.) of central California.

The heartwood is a clear yellow color and has a rather distinctive and somewhat unpleasant odor.

Anatomically *Torreya* is very similar to *Taxus*, however, it may be separated from *Taxus* by the paired appearance of the spiral thickenings, and the smaller (about 6 μ) size of the cross-field pits.

Tsuga

The genus *Tsuga* consists of four species: western hemlock (*T. heterophylla* (Raf.) Sarg.) and mountain hemlock (*T. mertensiana* (Bong.) Carr.) of the northwestern United States and southwestern Canada, and eastern hemlock (*T. canadensis* (L.) Carr.) and Carolina hemlock (*T. caroliniana* Engelm.) of the eastern region. *T. canadensis* occurs in the Lake States, northeastern United States, and southeastern Canada, and *T. caroliniana* is of limited occurrence in the Central Appalachians.

The woods of this genus show no difference between

sapwood and heartwood and bear a close resemblance to the wood of the western *Abies* with which they are frequently confused. Anatomically they are readily separated from the *Abies* by the ray tracheids which are always present in *Tsuga* and rarely present in *Abies*. The eastern species may be separated from the western species by the more abrupt transition from earlywood to latewood and the frequent biseriate bordered pitting that occurs in the former species. The western *Tsuga* may be separated from the western *Abies* by its more uniform and somewhat purplish color as seen on smooth cut end-grain surfaces and finer texture as seen with a hand lens. In the *Abies* species the color change from earlywood to latewood is more abrupt and the summerwood generally is light brown. The texture of the western *Abies* is distinctly coarser than that of *Tsuga heterophylla*.

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Standardization of the Jumbo Mullen Tester

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Bursting strength is an important property of linerboard, but unfortunately it is difficult to obtain consistently reliable test results. Even after carefully following check procedures, the operator is never sure of results since there is no basic standard. Other investigators have tried various standards, such as aluminum foil and selected uniform papers. These have drawbacks in that although they give constant Mullen results, their characteristics of stretch and smoothness are different from linerboard. We have had instruments which would check well with these standards, but would not give reliable tests on linerboard. We decided to use 42-lb. linerboard itself as a standard. Although its variability is quite high, we felt it could be overcome by testing a large number of standard samples. To implement this approach, we prepared a large group of 6-in. square pieces of linerboard. These were randomized and a large sample tested to obtain an average for the large group of samples. Using these data we determined that 20 samples per machine were necessary to give our desired precision. These data are plotted on a modified control chart with limits to indicate when corrective action is necessary. This technique has been successful in the early detection of instrument errors and has provided a positive check as to when these errors have been corrected.

In common with all who use the Mullen tester as a means of evaluating board, we have had nothing but headaches. The voluminous literature on this machine testifies better than anything else to the difficulties of consistently producing reliable tests which will check with those run by other laboratories. The first reaction of anyone working with the instrument is that its only virtue is its speed of operation. However, the Mullen value continues to appear in many paper specifications and remains the major strength specification for linerboard. As long as this continues, we who use or make such paper must, of necessity, be concerned with testing for bursting strength as accurately as we can.

To a manufacturer of linerboard, maximum accuracy of burst testing is a must; the cost of errors is tremendous, since nearly all board production is controlled to a specified bursting strength level. Should a Mullen tester be giving values 5% low, the board will be made with burst that is 5% higher than necessary. In our case this means that the machine is slowed down unnecessarily which, in turn, means less production and smaller profits. On the other hand, Mullen tester errors on the high side mean that the product is actually inferior. Such a product all too frequently results in customer complaints and, if continued, loss of sales.

Much of the literature on Mullen testers is concerned with the many adjustments which are necessary to keep the machine in satisfactory calibration. McKee, Root, and Ayers (*1*) have covered this well, including measurements of the degree to which various maladjustments can alter the test. Faichney and Mason (*2*) have outlined the procedure used in Canada for aligning the machine. Our own procedure, a composite of these and other published methods (*3*, *4*), has been described by Kimble (*5*).

Even after carefully following the best known adjustment techniques, considerable doubt remains as to the accuracy of the test results. There is the possibility that the adjustments have not properly accounted for all of the variables or that some error was made in making these adjustments.

The best overall check would be a primary standard but none is available for this test. Customarily, in almost all mills, testers are compared with each other by alternately testing adjacent spots on a paper or board sample using the two machines involved. This is extremely useful for bringing testers into agreement but it still does not provide assurance that either of the two testers is correct or that either is giving the same results that it did in the past.

Several people have had considerable success in using aluminum foil as a standard for calibration. In England, aluminum foil has been established as the basis for industry-wide calibration of Mullen testers (*6*) with considerable success. Aluminum foil has the advantage of being relatively immune to humidity changes and also is quite stable with aging.

The greatest drawback in using aluminum foil, particularly for board Mullen testers, is its smoother surface. This results in its behaving considerably different from board in the clamp of the tester. Consequently, it will not accurately detect tester deficiencies resulting from improper clamping, since a properly adjusted Mullen tester will actually allow some slippage in the clamp. Thus, instruments that may be off by as much as 5% may appear correct when checked with aluminum foil. In addition, considering single sample lots, burst tests on aluminum foil are no less variable than similar tests on board. Also its distention at burst differs considerably from board; thus, it reacts differ-

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ently to Mullen tester errors associated with either diaphragm characteristics or air in the hydraulic system. We abandoned use of foil because frequently we found that testers which had appeared satisfactory when checked with aluminum foil were actually in error by 2 to 5% when testing our board.

Another standard used quite widely is specially selected pouncing paper (7). We also tried this standard but found that it was still so different from board that it was subject to the same type of problems as was the use of foil, although to a somewhat lesser degree. Machines adjusted to read the same on pouncing paper did not necessarily agree on our linerboard.

By the process of elimination we had by this time arrived back at the use of the product we wanted to test as the best standard. We reviewed all of the reported disadvantages of using board as a standard for Mullen tester calibration. It appeared that basically these reduced to three; board burst is quite variable within a given lot; bursting strength of board varies with its moisture content; and bursting strength of board may change as it ages.

We decided that these problems were not enough to prohibit the use of board as a standard; so we decided to try it. To minimize the aging effect, we allowed the lot of board we selected as the standard to age several months before use. This was based on the theory that most of the aging effects, if there were any, would occur soon after manufacture. After that any change should be quite slow. Actually, we expected that the change in our board due to aging would be negligible since we had never been able to detect any such change in carefully controlled studies where board was aged several years.

To minimize the effects of moisture content of board, we planned to make all tests under TAPPI standard atmospheric conditions. Fortunately, the curve of bursting strength change with moisture is fairly flat in the range of moisture found in equilibrium with these conditions. This also has the desirable effect of keeping the instrument temperature constant. Standard conditions are used in our test room at the end of the paper machines.

To overcome the problem of board variability we could use only brute force of numbers. By using a large enough number of specimens from the standard lot for each calibration, we found that we could bring the precision of the average to a satisfactory level.

In order to reduce the variability of our standard lot as much as possible, we had a 6-in. wide roll of 42 lb. board trimmed from near the center of a board reel. This minimized any cross machine burst variability. The 6-in. roll was then cut into about 50,000 sheets, each 6 in. square. These were randomized by tumbling in a corrugated container drum tester. While it would have been preferable to use a random number technique for randomizing, this appeared too laborious. Subsequent observations have indicated that the tumbling technique was quite adequate.

Once the standard lot was prepared, we tested a total of 1600 specimens from the lot, in groups of 200, to obtain a reliable estimate both of the sample variability and its average bursting strength. Groups were limited to 200 samples in this phase to avoid the effects of fatigue on the rubber diaphragm. To further reduce the variability, all tests were made with the top (finished) side of the board against the diaphragm. Before these tests, the Model A tester used had been checked as carefully as we knew how, to be sure it was in the best possible condition. Also, it had recently been found to check closely with the standard instrument used at The Institute of Paper Chemistry for the program of the Fourdrinier Kraft Institute.

Table I

Sample size	*Precision[a] of average*
10	±5.1
40	±2.5
100	±1.6
250	±1.0
1000	±0.5

[a] 95% confidence level.

We found that the average burst of the lot was 98.5 ± 0.4 and the variability was such that the standard deviation of individual tests was 8.0. Based on this variability, we then calculated the number of samples needed for the desired degree of precision for the average. The precision for several different numbers of specimens is shown in Table I.

After we had been using this standard lot for some time we recalculated our average value and found (based on 6000 tests) that the average was 98.7 ± 0.2. This is the value we now use for this standard lot. No change was found in the sample variability.

Our next step was to set up control charts for each of our three Model A Mullen testers that are used routinely. To keep the labor at a reasonable level, and to conserve our standard sample, we selected 40 specimens as satisfactory for an individual check. We then established controls for the 40 specimen average at both the 1 sigma and 2 sigma limits on the chart. These are at $1^1/_4$ and $2^1/_2$ units each side of the average value (now 98.7).

Our procedure is to test 40 specimens on each active Mullen tester every other day. The average value is plotted on the control chart for that tester. Such a chart, selected when we were having more than usual calibration difficulties, is shown in Fig. 1. Should any value fall outside the outer limits (solid lines) as at point A, the instrument is immediately taken out of service until corrective action has been taken by our instrument maintenance crew. Two successive points falling outside the inner limits (dotted lines) on the same side are also a signal for immediate corrective action. As soon as the instrument crew has checked and readjusted the instrument, a recheck of 40 specimens is made. The results of such rechecks are shown at the points marked C.

The use of control charts has in no way replaced our routine maintenance checks on these instruments. These are still made on a regular schedule, the nature of any necessary adjustments is noted on the chart, and such adjustments are immediately followed by a recheck of 40 specimens from the standard lot. Unless this recheck average falls within the inner control limits, further maintenance work is done until the average for a subsequent recheck does fall within the inner limits. Such a recheck is shown at point D. In this case, the diaphragm was changed because the maintenance check showed that the pressure at standard distention was below the limits we allow for this check.

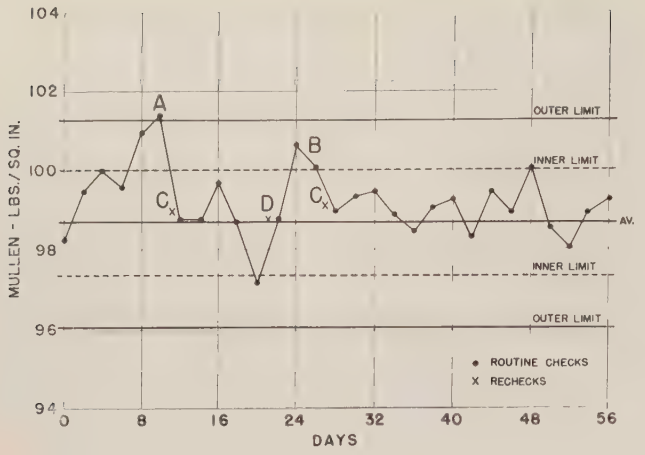

Fig. 1. Control chart used for Jumbo Mullen tester calibration

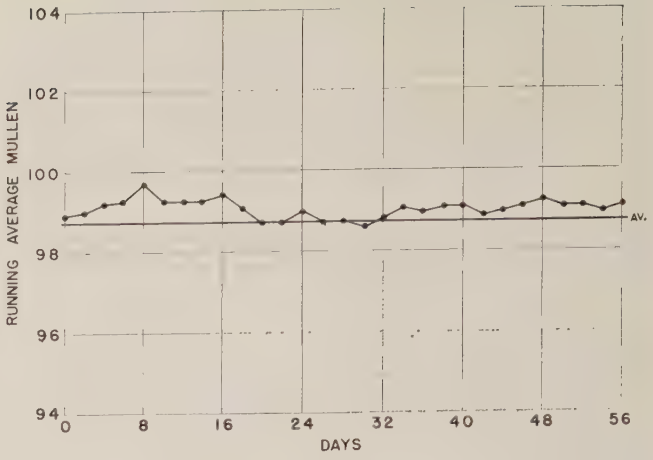

Fig. 2. Running averages of last five burst checks (200 determinations)

You will note that the routine calibrations had already warned of impending trouble before this diaphragm change, as indicated by the downward trend evident just prior to the change.

In addition to plotting the average for each check, we also plot the running average of the last five checks (200 pops). This is shown in Fig. 2. As you can see, the variations have been leveled out considerably. While no statistical controls are applied to this plot, it is also watched because it highlights long term trends which might be overlooked because of the variability of individual check averages.

To check on any possible change of our standard with age, we examined the averages on each machine over a long period. We felt that any change in the sample would be shown by a gradual drift on all three machines. No such drift occurred. Also, our tests on one of these instruments continue consistently close to the values obtained on duplicate samples tested monthly on the standard instrument at The Institute of Paper Chemistry.

Detailed instructions have been issued to the routine control personnel covering the application of this procedure. A copy of these instructions is appended.

It is apparent that these control charts have proved invaluable in keeping our instruments in calibration. Since their inception we have had two cases where customers reported that their bursting strength tests on our board were lower than we claimed. Armed with the confidence supplied by our control charts, it was relatively easy to resolve these tests discrepancies Even when we were having abnormal trouble, as during the period covered by Fig. 1, we successfully maintained the accuracy of our instruments so the average test over this period was off by only 0.4%.

We have three Model A Mullen testers that are regularly checked by this procedure. During the last month the checks with our calibration standard for the three testers have averaged 98.4, 99.3, and 100.1, as compared to our standard average of 98.7. The machine that averaged 100.1 has had considerable mechanical trouble and consequently has been out of service for much of this period. Without the calibration standard this trouble would probably have continued undetected. It is interesting to observe that our system is able to detect this error which is only 1.4%. We feel that the other two machines are in excellent control; and we attribute this to an excellent routine maintenance program combined with prompt special servicing whenever called for by the calibration checks.

While this paper covers our initial application of this technique, which was on our Model A testers, we have found that the same technique is equally effective when used for control of our Model C testers. We are now extending the use of this technique to other testers, particularly our tear and Concora flat crush instruments.

APPENDIX—MULLEN CALIBRATION PROCEDURE

Checking against Standard Samples of Liner: Every other day all Model A Mullen testers will be checked on specially selected samples of 42-lb. board. The following schedule will be followed in checking instruments: The samples of liner to be used are in the form of 6 by 6-in. squares. These samples should be preconditioned for at least 72 hr. in the preconditioning cabinet and then conditioned for at least 72 hr. at standard conditions before using.

Tester no.	*Shift*	*Dates of each month*
H-1	6–3	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30
H-3	3–11	1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31
H-5	11–7	1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31

Forty samples are to be used for each test. The tests will be made with the *top side of the sample against the diaphragm*. The average of the 40 tests is plotted on the control chart. If the average falls above or below the outer control limits, the instrument will be taken out of service and the instrument man must be notified to check the instrument. At the conclusion of the instrument man's checks an additional set of 40 samples will be tested and the average plotted. This procedure will be repeated until the average falls within the dotted lines. Plot on the chart also the running average of the most recent five (200 bursts) acceptable checks, which is to include the current bi-daily check. The instrument will not be put into routine service until these checks are completed.

If two successive averages of 40 samples (including rechecks) are both above or both below the inner con-

trol limits, the instrument will then be out of service and the instrument man must be notified to check the instrument. After the completion of these checks, a set of 40 samples will be tested and the average computed. This average will be plotted, and, if inside the two dotted control limits, the instrument will be placed back in service. If outside the dotted control limits, the instrument man should be recalled for further checking. This procedure will be followed until a sample average falls within the dotted lines.

At any time any maintenance work is done on the instrument, the procedures outlined in the above paragraph will be followed, i.e., diaphragm change, gage change, etc.

Whenever any work is done on any of these instruments, a notation of what was done should be made on the chart. All rechecks should be plotted on the chart.

Each of the control chart forms will be used for about 10 weeks. The last previous chart and the current chart will be posted near the Mullen tester, and all other charts will be sent to the laboratory.

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Scrubbing Kraft Recovery Furnace Gases

J. S. MURRAY

The Everett kraft mill of the Weyerhaeuser Co. experimented with various recovery furnace flue gas pilot-plant scrubbers to determine if the fly ash remaining after an electrical precipitator could be removed successfully. Results indicated that a spray-nozzle, venturi-throat scrubber would remove about 90% of the sodium salts from the flue gas. A full-size, stainless steel scrubber was installed and tested. Results indicated that the plant scale unit normally removes about 90% of the fly ash.

The Weyerhaeuser Co. constructed a 350-ton-per-day bleached kraft pulp mill in Everett in 1953. The recovery system for this mill included the normal equipment for efficiently removing fly ash from the furnace gases. A Babcock & Wilcox furnace was followed by a cyclone evaporator which picked up fly ash with a black liquor spray. A Cottrell precipitator was also installed. This unit removed 93% of the remaining fly ash when it was tested by the manufacturer.

The mill was built to effectively utilize the waste wood from Weyerhaeuser's Everett sawmills. It is located so that the prevailing winds will normally dissipate the mill's plume over nonresidential areas. It was also located so that it would be close enough to the sawmills to obtain chips by belt conveyor.

The mill was located near a residential area and the variable direction of the wind created a problem caused by the small amount of fly ash remaining after the precipitator which escaped from the stack. The general problem could be broken down into several steps: (1) how should a device to remove this fly ash be evaluated; (2) how effective is the equipment sold for this purpose; and (3) how effective would a full-scale installation be.

TESTING PROCEDURE

The method for determining fly ash used by the manufacturer of the precipitator was to withdraw a certain volume of flue gas through a paper thimble. The flue gas samples were withdrawn at isokinetic conditions; that is, at the same rate as the velocity of gas in the stack or flue. The weight of fly ash for a predetermined gas volume was calculated and related to the total quantity. Moisture was condensed and the amount calculated and corrected to a true gas volume.

This method proved to be quite difficult. The thimble would absorb moisture and collapse, or the hot flue gas might char it. In addition, the condensate collected after the thimble proved contaminated with chemicals. This indicated that in most cases this method would not trap all the fly ash as the flue gas was pulled through the paper thimble.

Samples were then withdrawn and the fly ash caught on the thimbles was dissolved in the condensate. Standard alkalinity tests were made, but these results proved inconclusive. This was caused by variations of pH due to interfering carbon and sulfur dioxides.

Before running further tests it was desired to find a method that could be used which would not be affected by the temperature of the flue gas or its pH.

Gravimetric analysis indicated that the fly ash consisted mainly of sodium sulfate, sodium chloride, and sodium carbonate. Since all these salts are soluble in water, and sodium was common to each salt, a technique for determining sodium-ion concentration was designed.

The Beckman spectrophotometer can easily measure small quantities of sodium ion in solution with reasonable accuracy. A standard solution of sodium chloride is used as a reference.

The next step was to design an absorption train that would trap all the sodium salts. Three flasks with fritted gas bubblers were first used as an absorption train. This unit would absorb the solid salts and operate satisfactorily at first, but at certain times small particles of carbon soon plugged the bubblers.

Since straight glass tubes did not give fine bubbles, the next problem that developed was to determine the

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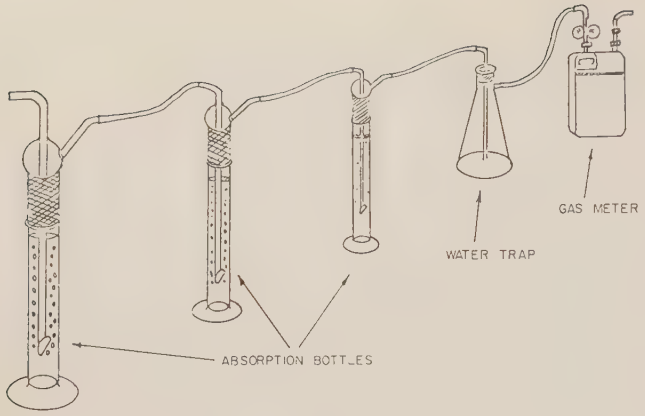

Fig. 1. Absorption train

efficiency of the absorption train itself. Using three flasks in series, the last bottle after a test was found to contain only trace amounts of sodium ion while the first bottle contained 80 to 90% of the total sodium ion.

The first bottle had to be kept in a cold-water bath, as the hot flue gas caused the absorbing solution to boil and sodium was carried over to the next flask. A small laboratory condenser was used ahead of the first flask if flue gases were extremely hot.

With satisfactory techniques developed both to absorb and to analyze the fly ash in the flue gas, several tests at various conditions could be made in one day. The apparatus used is shown in Fig. 1.

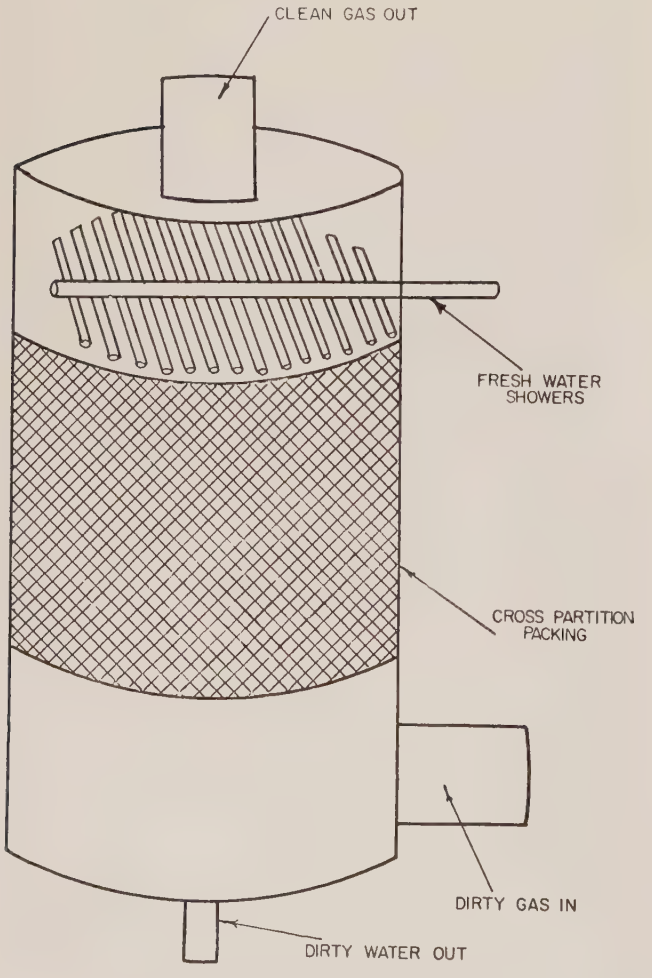

Fig. 2. Packed tower

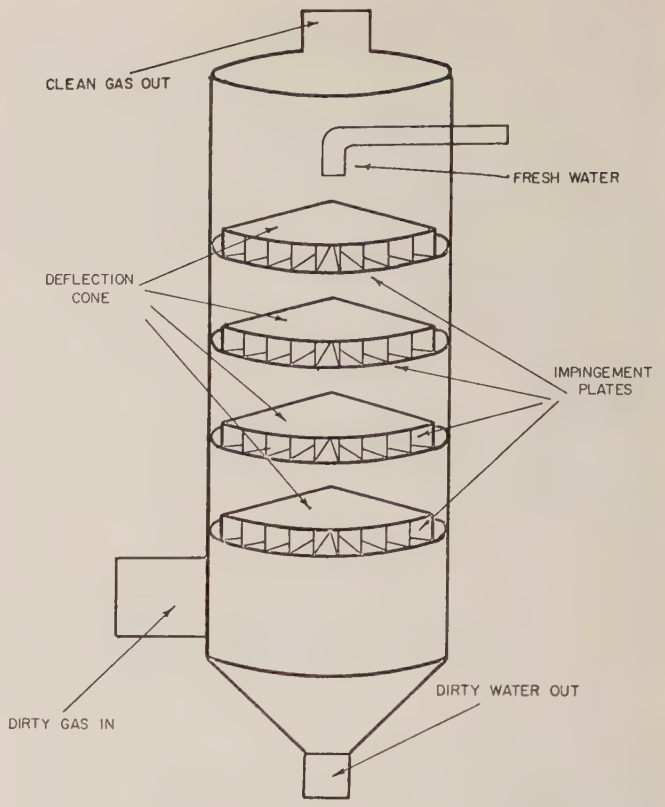

Fig. 3. Deflection impingement scrubber

PILOT-PLANT RESULTS

Several different types of scrubbers were tested to determine how effective they were in removing sodium salts from our flue gas.

Scrubber A

A 6-ft.-diam. packed tower was available at the mill, so it was decided to test it on our recovery furnace gas. A 24-in. diam. flue brought part of the gas from the furnace plenum chamber after the Cottrell to the bottom of the experimental packed tower. Fresh water entered the top of the tower through a header. The water flow was countercurrent to the gas stream. Variable volumes of flue gas were drawn through the tower with a 15-hp. motor and fan. The gas was exposed to ceramic 3-in. dumped, cross-partition tile packing. The packing was 6 ft. in depth. This unit is shown in Fig. 2.

The flue gas density was about 0.0498 lb. per ft., the temperature 300°F., and the pressure drop 1 in. per ft. of packing. Handbooks indicate that the water flow might range from 5 (dry tower) to 200 g.p.m. (flooded tower).

Several problems developed when this unit was first tested: (1) the water pressure at the elevation of the experiment was not sufficient to deliver enough water; (2) the distributor header did not give uniform flow; and (3) entrained chemicals in the exit gas from the tower resulted in very low efficiencies of 40 to 60%.

These problems were overcome with high-pressure fire-main water, a repositioned header, and the establishment of a moisture-entrainment baffle.

Another series of tests on the scrubber found the efficiencies to range from 65 to 75% dust removal. Water usage was 35 to 50 g.p.m. per 1000 c.f.m. For a full-size unit the fan would require about 225 hp.

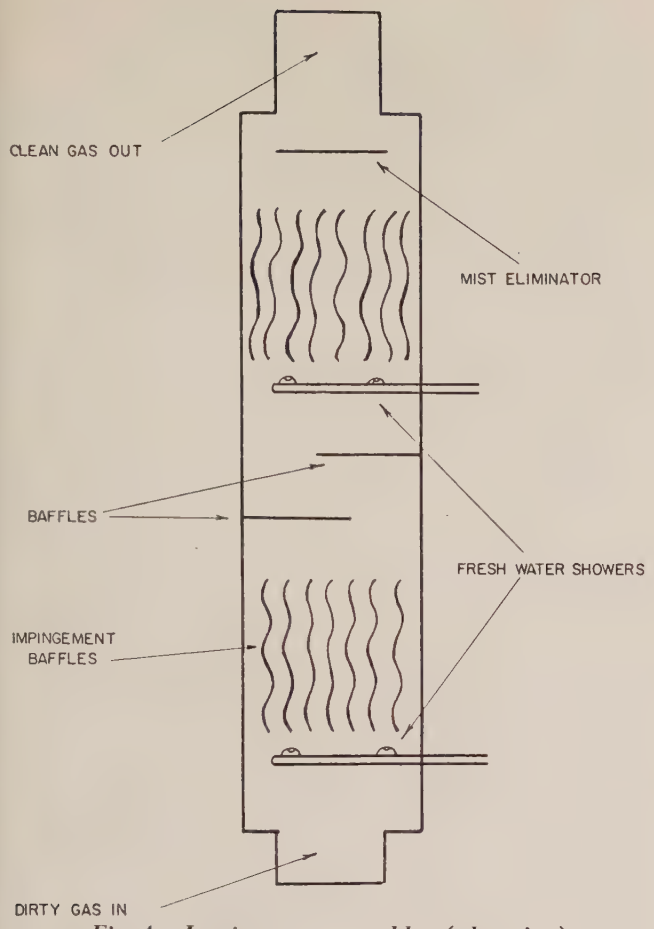

Fig. 4. Impingement scrubber (plan view)

and the cost for the full-size scrubber and fan would be about \$0.89 per 1000 c.f.m.

Scrubber B

A commercial pilot-plant scrubber supplied by the manufacturer was the next unit tested. This scrubber was installed on the fifth floor of the powerhouse and was connected to the plenum chamber.

The scrubber was a countercurrent, vertical impingement-plate unit. This is shown in Fig. 3. Flue gas passed upward through a series of inverted cones. Water cascaded over the apex of the cone and ran down the face of the cone to contact the flue gas. This scrubber consisted of six individual stages.

According to the manufacturer, this type scrubber was designed for removing particles larger than 1 to 5 μ.

The required quantity of scrubbing water was originally estimated at 3.0 g.p.m. per 1000 c.f.m. of flue gas. This ratio was tested and efficiencies ranged from 50 to 60%. Later information from the manufacturer indicated that the quantity of water could be as high as 8.0 g.p.m. per 1000 c.f.m. Again, efficiencies were in the 55% range. For the final series, the water rate was increased to 20 g.p.m. per 1000 c.f.m. The maximum dust-removal efficiency observed under these conditions was 72%.

Inspection of the scrubber before the last series of tests indicated that fly ash was by-passing the bottom stages. It was observed that fly ash was caked on the bottom of the middle baffle and header pipe. The water-distribution pipe of the unit did not allow the scrubbing agent to flow evenly over the entire surface

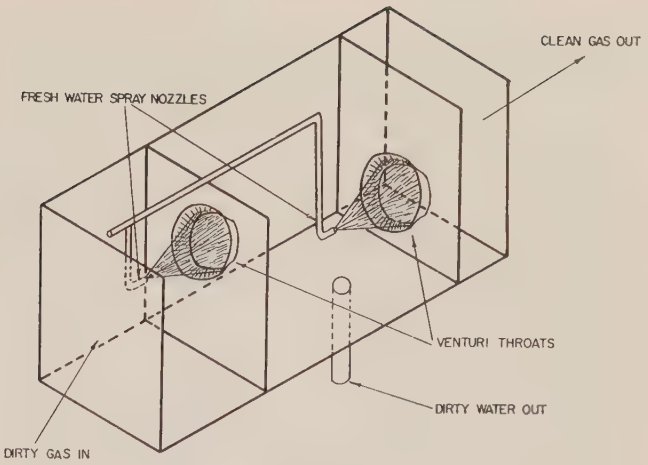

Fig. 5. Spray venturi scrubber

area of the cone plate. This allowed a certain volume of unscrubbed flue gas to escape.

The higher gas velocities and large quantities of cold, fresh water did increase efficiencies slightly, but these rates were well beyond the design conditions of the scrubber.

A full-scale unit operating at a 10-in. pressure drop would require a 360-hp. fan and would cost \$1.13 per c.f.m.

Scrubber C

A pulp mill located in the southeast installed a pilot-plant scrubber to operate on the recovery flue gases following their Kopper's electrical precipitator. Their tests proved that the unit was successful in removing "soda-ash" dust from the exhaust gases. From their results they decided to erect a full-scale scrubber.

Since the pilot unit was available after their tests were completed, we obtained it. The scrubber was installed directly below the plenum chamber and connected in a manner that would allow us to blow flue gases through the unit. This scrubber was a horizontal, nonpacked, impingement-plate unit. It is shown in Fig. 4. Water cascaded over vertical plates, and flue gas contacted the scrubbing agent at a modest velocity.

Initial tests indicated that the scrubber would operate with efficiencies around 80%. It appeared that even greater efficiencies could be obtained if it were not for the entrained mist from the last spray of the scrubber. Mist-removing baffles were added after the last section. Efficiencies were then increased to an average of about 85%.

This scrubber was designed to use variable ratios of fresh to recycle water, but the optimum efficiency was obtained when using all fresh water.

The main advantages to this type of scrubber on full-scale operation would be low power (50 hp.) and low water usage (3.0 g.p.m. per 1000 c.f.m.). Disadvantages to the scrubber would be carry-over mist entrainment and cost (\$3 per c.f.m.).

Scrubber D

This scrubber was a horizontal unit containing spray nozzles with adjacent venturi-throat pieces. It is shown in Fig. 5. Four of these units were placed in series. Water at a pressure of 40 p.s.i. and a rate of 5 g.p.m. was sprayed through the throat pieces. The

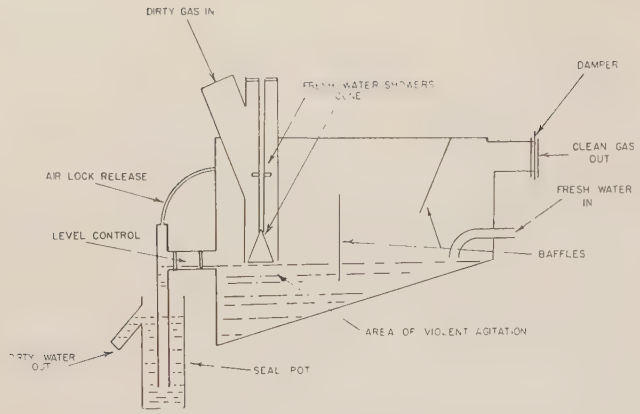

Fig. 6. Turbulence scrubber (elevation view)

spray made contact with the small fly-ash particles as the flue gas was pushed through the constricting venturi.

The scrubber operated properly on the first series of tests, with efficiencies greater than 80%. Water ratios were varied until it was found that a ratio of one bank fresh to three banks recycle resulted in an efficiency of about 75%.

Visual observations through sight-glass holes indicated that the spray pattern was not filling the throat properly. The lid of the scrubber was removed and it was found that the nozzles were plugging with carbon and sand in the first three banks. Cleaning these nozzles did not solve the problem, as they again became plugged.

Several different styles of nozzles were tested until it was found that a nozzle manufactured by Spray Co. was completely satisfactory. This nozzle was also the least expensive, the easiest to clean, and it emitted a finer, fuller spray pattern.

These nozzles were installed in the scrubber at a new distance from the throat piece. Using all fresh water, at a rate of 10 g.p.m. per 1000 c.f.m., efficiencies were in excess of 96%. Using a ratio of one bank of fresh to three banks of recycle, efficiencies were about 90%. By staggering the banks, the efficiency was increased slightly.

An attempt to use all recycle water was tried in order to concentrate and save the dissolved chemicals. Water vapor in the flue gas would condense and give an overflow from the scrubbing system, even though no fresh water was added.

This method of scrubbing worked at first, but as the hot flue gases heated the recycled scrubbing agent the efficiencies decreased. It was concluded from these tests that the condensing action of a relatively cold scrubbing agent was necessary to allow high efficiencies.

Cooling coils in the recycle system were considered, but this idea was abandoned when it was calculated that the scrubbing agent could not be concentrated enough to make its saving worth while. There was too much condensation from stack vapor when the temperature was lowered to an efficient level. There also appeared to be an advantage in allowing the sodium chloride in the fly ash to be removed from the system, rather than to be recycled and load up our recovery system with an inactive salt at concentrations that might cause corrosion problems. The sodium chloride in our fly ash comes from salt-water-borne logs.

There was no pressure drop across this scrubber. The driving force of the fine spray impelled the flue gas through each section.

Larger throat pieces and nozzles were tested to see if the number of individual units could be reduced. These tests indicated that the larger units would not be as successful as the smaller throats and nozzles.

Since the small throats and nozzles did a satisfactory scrubbing of flue gases, this type of unit was fabricated and installed between the precipitator and the stack.

This scrubber could be operated with 4.0 g.p.m. per 1000 c.f.m. minimum fresh water, or 16.0 g.p.m. per 1000 c.f.m. maximum for optimum efficiency. The cost would be about $1.27 per c.f.m.

Scrubber E

After the full-size installation was made, another pilot-size scrubber was tested to determine if it could substitute for an electrical precipitator or be used in future construction at other Weyerhaeuser locations.

This scrubber operated on the principle of high turbulence of flue gas with an impingement liquid. The design is shown in Fig. 6. Flue gas was pulled through a small, circular orifice placed at a critical distance from the scrubbing agent.

The scrubber was first connected to the flue ahead of the Cottrell. Pressure drop across the scrubber and the distance between the throat and the scrubbing agent were critical. If the pressure drop created by a suction fan was too low the scrubber was inefficient, due to lack of turbulence. Too high a pressure drop caused excessive mist carry-over and the fan would not operate. After the proper pressure-drop range and the corresponding variable—cone to water distance—were found, several tests were made on this unit. Efficiencies ranged from 58 to 72%.

The main purpose of this scrubber was to substitute for a precipitator and, since black liquor was presently used in the Cottrell hoppers, this agent was then used.

Several problems quickly developed in attempting to use weak black liquor at 17% solids as the scrubbing agent. Any carry-over immediately made the scrubber inefficient because the black liquor contained high concentrations of sodium ion and a few drops made the exit load higher than the inlet load.

The black liquor was considerably hotter than fresh water and the scrubber lost its condensing action. The resin soaps in the black liquor and the high turbulence caused a serious foaming problem. This foam carried over into the fan and overloaded the motor.

Sodium efficiencies at the best conditions were less than 5% when black liquor was used.

Heavy black liquor, 50% solids, was also unsuitable because this medium was too viscous for any turbulence to occur.

Since this unit was unsuccessful ahead of the Cottrell, the breeching was modified and reinstalled after the precipitator.

Water rates were varied from 0.6 to 5.5 g.p.m. per 1000 c.f.m. The pressure drop across the unit was varied from 6.0 to 11.5 in. of water. The optimum conditions were at 1.0 g.p.m. per 1000 c.f.m. at 7.0 in. water-pressure drop. Efficiencies were over 98% removal.

The low water usage was a good advantage for this

Table I. Summary of Scrubbers Tested

Scrubber	Type	Initial cost (stainless steel), $/c.f.m.	Water usage, gal./1000 c.f.m.	Horsepower	Efficiency, %
A	Impingement packed	0.89	35.0 to 50.0	225	70
B	Impingement plate	1.13	20.0	360	70
C	Impingement baffle	3.00	3.0	50	85
D	Spray venturi	1.25	16.0	None	90
E	Turbulence	1.15	1.0	125	98

unit, as well as its moderate fan requirements. Its cost was in the same range as the scrubber we selected (about $1.15 per c.f.m.).

It was concluded that this type of unit would operate satisfactorily after our present Cottrell, but definitely not as a substitute for our precipitator.

Summary of Pilot-Plant Results

A comparison table, relating the initial costs, water usage, horsepower requirements, and efficiencies of the various scrubbers tested, is included below.

FULL-SCALE INSTALLATION

A stainless steel body, 30 ft. by 30 ft. by 20 ft., was erected adjacent to the breeching between the Cottrell and the recovery stack. The scrubber contains 473 individual spray nozzles and venturi throats in four separate, staggered banks. Piping to the shower was designed to allow the use of either fresh or recycle water or a combination of both. Two 1800-g.p.m. pumps were used to maintain 40-p.s.i. nozzle pressure. An automatic damper in the by-pass breeching was installed and controlled by Cottrell exit draft.

The scrubber was installed in a parallel path between the Cottrell and the stack west to the original breeching, as it had to be constructed during mill operation. The bends and baffles to the scrubber more than neutralized the positive draft effect that was observed in the pilot plant. A 100-hp., 180,000-c.f.m. fan was then installed to allow the scrubber to operate at its design conditions with no detrimental effects of the furnace draft.

After one month's operation, slight corrosion was evident in areas that were not wetted. This was mostly confined to the first bank. Additional water sprays were added to help eliminate this problem. Debris in the recycle system plugs some nozzles. These are cleaned or replaced whenever the recovery operation is shut down.

In the pilot-plant study, moisture entrainment was not a problem; but in the full-size scrubber, large quantities of water were carried over to the stack. This came out as rain in the stack and returned to the scrubber. To determine if this action increased the overall efficiency of dust removal, a sample point near the top of the 280-ft. stack was installed. Samples were withdrawn through a plastic tube and the sodium ion concentration was determined. These tests indicated that about 7% of the sodium ion concentration was removed by the rain in the stack after the scrubber.

The sample line from the top of the main stack was run to the powerhouse turbine room test bench. The regular powerhouse operators could then sample the scrubbed flue gas from the stack. A simple conductivity test was made on a sample through which flue gas was bubbled for a set period of time.

This was not successful because it varied with furnace conditions and vacuum supply. It was found that interfering ions caused the conductivities of the absorption solution to change with no difference in the sodium ion concentration.

The pilot-plant technique was then used for routine sampling. A gas meter was used to collect the sample and it was analyzed in our laboratory with the Beckman spectrophotometer.

This method gave a reliable sodium loss on a routine, daily basis. These tests have indicated that the scrubber normally removes about 90% of the sodium salts remaining in the flue gas after the Cottrell.

A Shibley Award paper presented at the meeting of the Pacific Section of Shibley TAPPI held in Camas, Wash., April 7, 1959.

Status and New Developments in Peroxide Bleaching of Pulps

F. L. FENNELL, G. E. SMEDBERG, and N. J. STALTER

New developments in the use of peroxide for bleaching cold soda, groundwood, and kraft pulp are presented. Typical process layouts for peroxide bleaching cold soda pulp in refiners and towers are given, together with an outline of the chemical requirements and the bleaching results. Data obtained in the refiner bleaching process show that under certain conditions there is a significant bleaching advantage when sulfuric acid is used for partial neutralization of the caustic-treated chips just prior to or simultaneously with the peroxide addition as the chips enter the refiner. Laboratory data also compare the bleachability of cold soda pulps prepared from representative hardwood pulp mixtures from the south, northeast, and north central areas. A high-temperature groundwood bleaching process has been developed in the Du Pont laboratory using peroxide at 200°F. for a period of 10 min. to produce groundwood with a brightness comparable to that obtained with conventional processes operating at 100–110°F. This high-temperature peroxide bleaching process was developed primarily to meet the needs of the smaller groundwood mills for reduced capital investment in line with reduced tonnage requirements. The effect of the common variables such as time, consistency, alkalinity, and peroxide concentration are given. Data are presented showing that peroxide can be used with technical and

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economic advantage in five- and six-stage bleaching processes operating with one or two stages of chlorine dioxide. The five-stage process at Marathon Southern, Naheola, Alabama—chlorination, caustic extraction, calcium hypochlorite bleach, chlorine dioxide, peroxide—is described; the chemical concentrations employed and the bleached pulp results are included.

THE use of peroxide for pulp bleaching has grown steadily since 1945. About 50 U.S. mills are using it for bleaching four types of pulp, groundwood, kraft, sulfite, and cold soda pulp.

The status of peroxide in U.S. mills is shown in Table I.

COLD SODA PULP BLEACHING

Peroxide processes have been installed in all new bleach plants for cold soda pulp. Two types of applications have evolved:

1. Bleaching in the refiner for moderate gains up to 55–65 brightness.
2. Bleaching in towers for brightness gains up to 65–75 brightness.

Peroxide Bleaching in Refiners

Two mills are in operation and two additional installations are under construction. A typical refiner bleaching process is shown in Fig. 1.

Caustic-treated chips and peroxide solution are metered to the refiner, with steam and water added as required for proper refining and control of bleaching conditions. The pulp is bleached for about 15 min. at 170°F., then neutralized with SO_2 to pH 6.0 and diluted for screening and cleaning operations.

The chemicals used in the bleaching process, as determined by pilot plant runs, are outlined in Table II.

Sulfuric acid has been required in most cases for controlling the peroxide solution alkalinity during refiner bleaching operations. The acid and the peroxide solution are added to the chips just prior to entering the refiner. The neutralization step with sulfur dioxide is carried out when the residual peroxide is 15 to 25% of the initial concentration.

Table III shows the effect upon bleaching when sulfuric acid is used in the process.

Peroxide Bleaching in Towers

Cold soda pulp made from beech, birch, and maple hardwoods is being bleached from 45 to 80 brightness using a two-stage peroxide-hydrosulfite bleaching process (Gould Paper Co., Lyons Falls, N. Y.), as shown in Fig. 2.

Unbleached, screened pulp is washed, acidified to pH 2.5 with sulfuric acid, then washed again with warm water. Steam is added at the double-shaft mixer; the pulp passes through the high-density pump where the peroxide solution is added, then through a single-shaft mixer prior to the pulp tower. The peroxide tower bleaching treatment is carried out at 12% consistency for 2 hr. at 170°F. Following the peroxide treatment, the pulp is diluted and pumped to an agitated neutralizing chest where the temperature is adjusted to 140°F., the consistency is controlled at 4% and the pH adjusted with sulfur dioxide to 6.0. Sodium hydrosulfite is mixed with the pulp at the pump en route to stage-two tower for treatment at 140°F. for 1 hour. After the hydrosulfite treatment, the pulp is washed and pumped to the bleached pulp storage chest. The chemicals used in the bleaching process are given in Table IV, and the bleaching results in Table V. Peroxide produces 25 to 30 units of brightness increase; hydrosulfite contributes an additional 5 units of pulp brightness.

The acidification step is essential to the success of the process in this mill. The acid treatment is responsible for an additional brightness gain of about 10 units in the peroxide stage, accompanied by a marked increase in the stability of the peroxide solution in contact with the pulp; if the acid treatment is omitted, the second stage hydrosulfite treatment does not compensate for the loss in efficiency in the peroxide stage. The benefits of the acidification step are probably due to the fact that metal ions with catalytic effect upon peroxide decomposition are solubilized and removed in subsequent washing.

The time-temperature relationship in the peroxide

Table I. U. S. Pulp Mills Bleaching with Peroxide

Pulp	*Total bleached, M tons/yr.*	*Peroxide bleached— No. of mills*	*M tons/yr.*	*% Bleached with peroxide*
Groundwood[b]	860	24	650	76
Kraft	4000[a]	16	740	18
Sulfite	1850[a]	5	240	13
Cold Soda (1960 est.)	150	6	150	100

[a] *Pulp, Paper & Board Industry Report*, U. S. Dept. of Commerce, Vol. XV, No. 1: 12, 17 (March, 1959).
[b] Newsprint excluded.

Table II. Chemicals Used in Cold Soda Refiner Bleaching Process

Chemical	*Per moisture = free ton, %*
Peroxide solution	
Sodium silicate	5.0
Hydrogen peroxide	0.6 –1.5
Sulfuric acid	0.4 –0.6
Neutralization after bleaching	
SO_2	0.75–1.0

Table III. Refiner Bleaching of Cold Soda Pulps from Southern Hardwoods using 1.25% H_2O_2

Unbleached brightness	*H_2SO_4, %*	*Pulp pH ex refiner*	*Residual peroxide from refiner, %*	*Bleached brightness*
38	..	11.0	3	47
38	0.6	10.5	65	60
41	..	11.1	5	48
41	0.6	10.0	50	56

Table IV. Chemicals Used in Cold Soda Bleaching Process

Treatment	*Chemicals used*	*Per moisture-free ton, %*
Acidification	Sulfuric acid	2.2
Stage 1—peroxide	Sodium silicate	5.0
	Sodium peroxide	1.2
	Hydrogen peroxide	0.75
Neutralization after peroxide	Sulfur dioxide	1.0
Stage 2—hydrosulfite	Sodium hydrosulfite	1.0

Table V. Peroxide-Hydrosulfite Bleaching Results on Cold Soda Pulp at Gould Mill

Treatment	*Brightness*
None	45
Stage 1—peroxide	73–75
Stage 2—hydrosulfite	78–80

stage is important because it was found that a brightness reversion can occur within the tower when the residual peroxide falls below 15 to 20%.

Peroxide Bleaching in du Pont Laboratory

Laboratory bleaching procedures simulating tower bleaching have been applied to various cold soda pulps with the results shown in Table VI and reference (*5*).

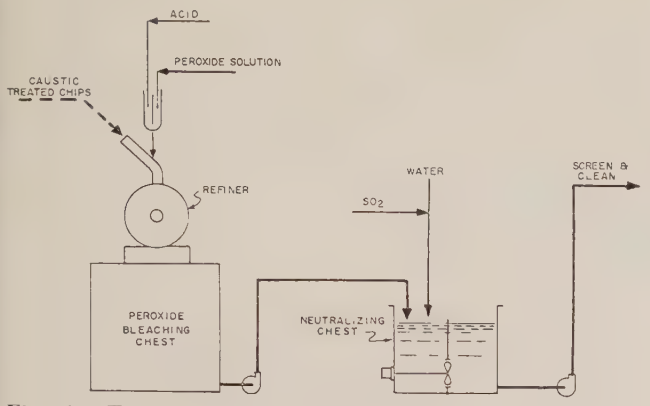


Fig. 1. Typical process for peroxide bleaching in the refiner

Because the bleachability of the cold soda pulp varies with the wood species and age, laboratory bleaching investigations are essential for planning the mill bleaching process.

GROUNDWOOD BLEACHING

The usual process for groundwood bleaching involves a peroxide treatment in towers for one to two hours at 110°F. and 12% consistency. A majority of these mills are in the 50- to 250-ton-per-day class. The pulp bleaching process represents an investment of several hundred thousand dollars to insure operating conditions for optimum chemical bleaching efficiency.

Experience indicates that mills requiring only 20 to 50 tons per day of bleached groundwood have difficulty justifying the capital investment for a conventional type process. In an effort to solve this problem, Du Pont studied the groundwood bleaching reaction at high temperature and found that groundwood can be bleached with practical efficiency in 10 min. at 200°F. This high-temperature bleaching process is proposed specifically for small tonnage mills, nonintegrated as well as integrated.

High Temperature Peroxide Bleach

Experimental Procedures. Source of pulp: Fresh, northern spruce groundwood with a brightness of 63 was frozen to insure uniform bleaching results during the period required to carry out this bleaching study.

Pulp treatment before peroxide bleaching: The groundwood was pulped at 2% consistency, treated with 0.25% Versenex 80 (pentasodium salt of diethylenetriaminepentaacetic acid from Dow Chemical Co.) on the moisture free weight of the pulp and then dewatered (but not washed) to pulp bleaching consistency.

Peroxide bleaching technique: Pulp pretreated and dewatered to bleaching consistency was blended thoroughly with the peroxide bleaching solution and the pulp sealed in a polyethylene bag. The bag was then submerged in a water bath at the desired bleaching temperature and kneaded at intervals to insure rapid, uniform heating. Weighed samples of the pulp were removed at intervals; one part was dumped into sulfuric acid-potassium iodide solution for a residual peroxide determination, the other part was dumped into water containing sodium metabisulfite solution and adjusted with sulfuric acid to pH 4.5 to 5.0 for handsheet preparation and brightness determinations.

All peroxide bleaching solutions were prepared to deliver 0.05% Epsom salt and 5.0% sodium silicate on the moisture-free weight of the pulp; the quantity of peroxide used was varied as shown in the data; the caustic soda was maintained at the optimum for the peroxide concentration employed.

Table VI. Bleaching Cold Soda Pulp in the du Pont Laboratory

Pulp composition	H_2O_2 *used, %*	*Brightness* — *Peroxide bleach*	*Brightness* — *Hydrosulfite bleach, 1%*
Beech, birch, maple (equal mixture) Brightness 46	0.4	65.0	
	0.8	70.7	
	1.2	73.5	77.1
50–50 Southern red oak, mixed hardwoods, Brightness 43	0.4	57.7	
	0.8	65.0	
	1.2	67.4	71.2
Aspen, Brightness 47	0.4	58.7	
	0.8	64.5	
	1.2	67.6	70.5

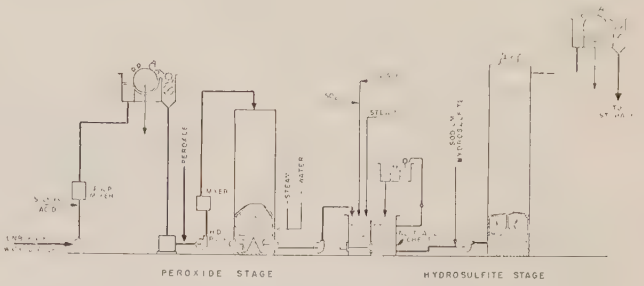


Fig. 2. Peroxide-hydrosulfite bleaching process for cold soda pulp

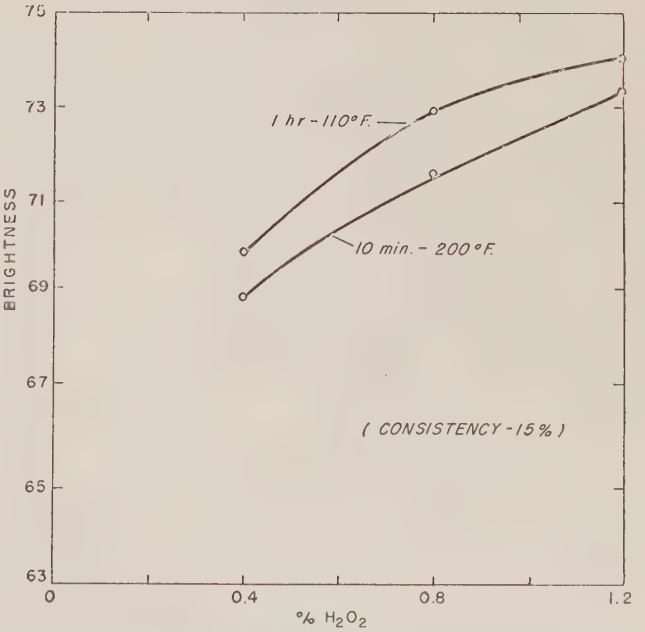
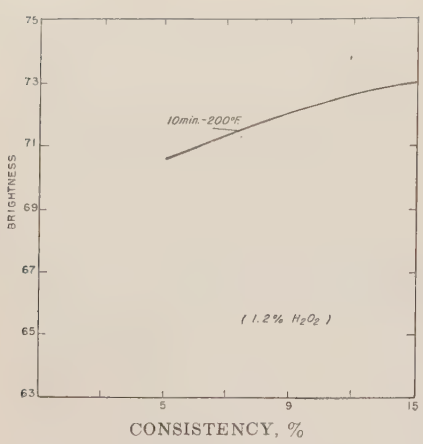
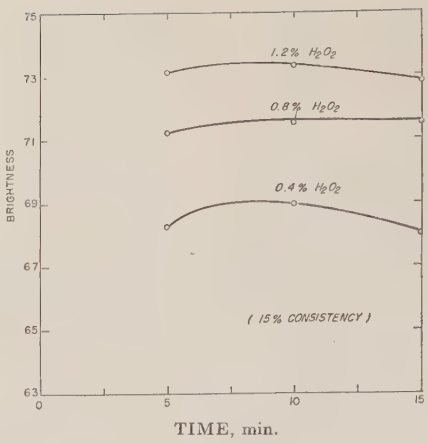


Fig. 3. Conventional vs. high temperature peroxide bleach on groundwood; effect of peroxide





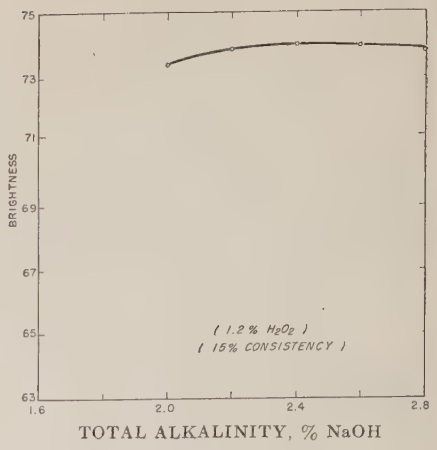


Fig. 4. (left) High-temperature peroxide bleach on groundwood, effect of consistency
Fig. 5. (center) High-temperature peroxide bleach on groundwood, effect of time
Fig. 6. (right) High-temperature peroxide bleach on groundwood, effect of alkalinity

Bleaching Results

Conventional vs. High Temperature Peroxide Bleach on Groundwood. The laboratory results, comparing conventional bleaching with high temperature bleaching at 15% consistency are shown in Fig. 3. As the peroxide application increases from 0.4 to 0.8 to 1.2%, the brightness increases at relatively equal rates in both processes. The brightness obtained with the high temperature method compares favorably with the conventional process.

Variables in the High Temperature Peroxide Process. Effect of consistency: The laboratory results show that the brightness increases as the consistency increases from 5 to 9 to 15%, as shown in Fig. 4.

Effect of time: Figure 5 shows that the pulp brightness increases slightly in the 5- to 10-min. interval and decreases about 0.5 unit at the 15-min. interval.

Effect of alkalinity: Figure 6 shows that when bleaching at 15% consistency the total alkalinity as NaOH, including the caustic from the silicate solution, is about 2.4% but is not critical within wide limits. A similar situation holds for low temperature peroxide bleaching.

Effect of pulp-peroxide mixing temperature: Figure 7 shows that it is important to mix the peroxide with the pulp prior to heating. Mixing at 70°F. shows about 1 brightness unit advantage over preheating the pulp to 200°F. before adding the peroxide. At the 5-min. interval this advantage is not apparent because the pulp-peroxide mixture requires most of the 5-min. period to come to the water bath temperature, thereby giving a slightly lower initial rate of brightness increase.

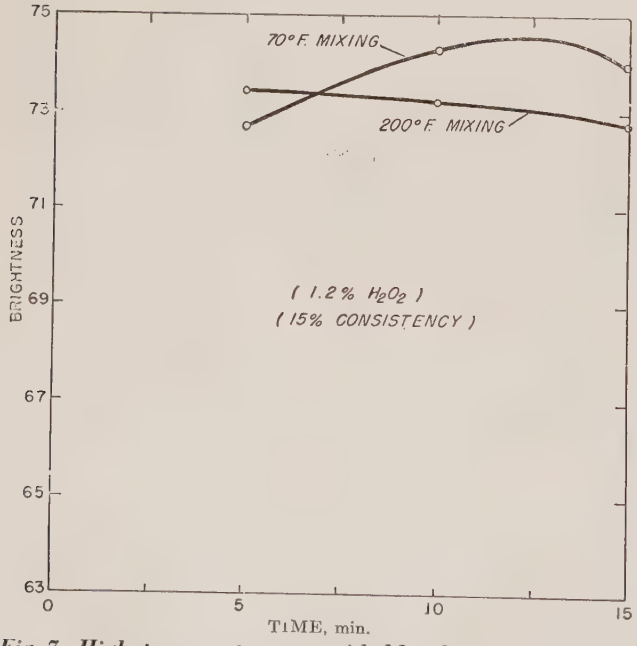


Fig. 7. High-temperature peroxide bleach on groundwood; effect of pulp-peroxide mixing temperature

Equipment Layout for High Temperature Groundwood Bleaching Process

The suggested equipment layout for the high temperature groundwood bleaching process is given in Fig. 8. The unbleached, deckered groundwood is treated with the peroxide bleaching solution in the conveyor en route to the high density pump. Steam is added at the high density pump and the pulp is retained for 10-min. bleaching at 200°F. in the stainless steel retention tube. Sections *A* and *B* are designed on the basis of the pulp consistency. For example, at 24 tons a day capacity with operations at 9% consistency, the required tube length is 19 ft., with a diameter of 24 in., with Section *A* 8 ft. and the tube curve 11 ft. The peroxide-bleached pulp is diluted with white water to 4% consistency and neutralized with SO_2

Tons day	*Consistency %*	*Retention time, min.*	*Pipe length, ft.*	*A, ft.*	*Curve, ft.*	*B, ft.*
24	5	10	34	15	11	8
24	9	10	19	8	11	0
24	15	10	11	0	11	0

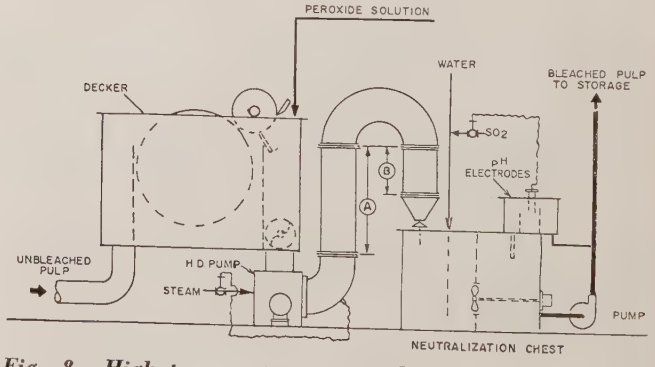


Fig. 8. High-temperature groundwood bleach process

Table VII. Peroxide after Chlorine Dioxide in a Five-Stage Process (CEHDP)[c]

Stage	Airdry	Brightness, Ovendry: 1 hr., 105°C.	Brightness, Ovendry: 3 hr., 85°C., 100% R.H.	Brightness, Ovendry: Ultraviolet exposure 30 hr.	Viscosity, cp.
Unbleached[a]	27.0	..	..	..	26.3
1. Chlorination	29.5	..	..	..	18.4
2. Caustic extraction	33.7	..	..	..	19.9
3. Hypochlorite bleach	70.2	..	..	..	16.9
4. Chlorine dioxide bleach	83.5	78.8	..	..	17.7
5. Peroxide bleach[b]					
H_2O_2, % 0.05	84.5	83.1	81.0	80.6	16.8
0.10	87.2	85.3	83.8	81.9	16.5
0.15	87.8	86.2	84.5	82.5	16.1
0.20	88.6	86.4	85.6	83.4	16.0
0.25	89.6	87.4	86.2	83.8	16.1
0.30	90.0	87.5	86.2	83.8	15.8

Chemicals Used

Stage	Chemical	% Used	Residual chemical, %
1	Chlorine	5.8	6
2	Caustic soda	2.5	..
3	Chlorine as sodium hypochlorite	1.05	7
4	Chlorine dioxide	0.60	10
5	Peroxide bleach[b]	0.05–0.30	25–50

[a] The chlorine demand of unbleached pulp was 9.7%.
[b] Peroxide solutions in all kraft bleaching reported in this paper contained 0.05% Epsom salt, 2.0% sodium silicate, and 0.3% NaOH on the moisture-free weight of the pulp.
[c] C = chlorination; E = caustic extraction; H = hypochloriter; D = chlorine dioxide; P = Peroxide.

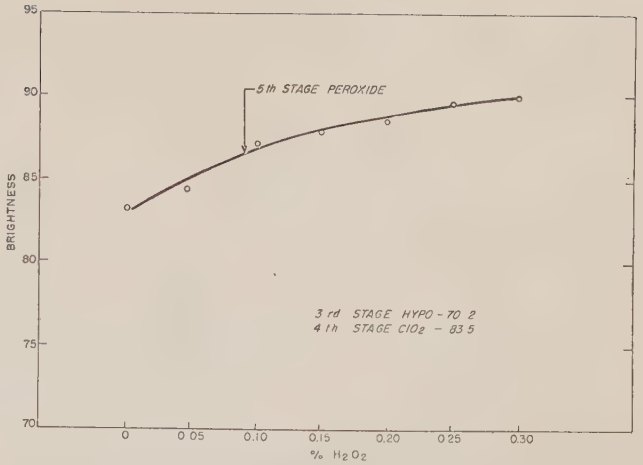


Fig. 9. Peroxide after chlorine dioxide in a 5-stage process (CEHDP)

peroxide either following chlorine dioxide or as a bleaching stage between two chlorine dioxide stages in order to produce special grades of high brightness pulp.

Various Chlorine Dioxide-Peroxide Combination Processes

The following data show that peroxide can be used with technical and economic advantage in multistage plants using one or two stages of chlorine dioxide. This work was carried out on 100% jack pine kraft obtained from the north central area.

Table VIII. Peroxide Between Chlorine Dioxide Stages in a Six-Stage Process (CEHDPD)

Stage	Airdry	Brightness, Ovendry: 1 hr., 105°C.	Brightness, Ovendry: 3 hr., 85°C., 100% R.H.	Ultraviolet exposure, 30 hr.	Viscosity, cp.
Unbleached. Same as Table VII					
1 to 4. Same as Table VII					
5. Caustic extraction	79.0	77.3	77.1	78.7	16.8
5. Peroxide bleach	Used 0.1, 0.2, and 0.3% H_2O_2, as shown in Table VII				
6. Chlorine dioxide bleach					

Stage 5 treatment →	0.3% NaOH			0.10% H_2O_2			0.20% H_2O_2			0.3% H_2O_2		
ClO_2 in Stage 6, % →	0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3
Brightness												
Airdry	88.4	89.1	89.4	91.0	90.5	91.5	91.3	91.8	91.4	90.8	92.2	91.9
1 hr., 105°C.	86.3	86.7	87.3	88.0	88.3	88.1	88.3	88.6	89.0	88.8	89.4	89.3
3 hr., 85°C., 100% R.H.	83.4	85.2	86.3	86.3	86.4	86.7	86.5	87.0	87.2	87.4	88.4	86.8
Ultraviolet exposure, 30 hr.	84.2	84.1	85.6	84.6	84.4	85.9	85.8	87.1	86.2	85.5	86.2	86.4
Viscosity, cp.	...	16.8	...	...	15.9	...	...	15.4	...	...	15.2	..

to pH 6.0 in the neutralizing chest. From the chest the neutralized, bleached pulp is pumped to storage.

KRAFT BLEACHING

Kraft bleach plants have used peroxide for 10 years for two purposes:

1. To obtain increased pulp brightness with no significant loss in strength.
2. To obtain good brightness stability.

During the same 10-year period most kraft bleach plants installed chlorine dioxide bleaching for obtaining a major portion of their pulp brightness increase. With this trend it was a natural step to try a chlorine dioxide-peroxide combination process. Experimental work in various laboratories had shown advantages for chlorine dioxide-peroxide combination systems (*1, 2, 3*). At present, one 350-ton a day kraft bleach plant has been operating over a year with a 5-stage process built specifically to use peroxide as a final stage following chlorine dioxide. Two or three other mills are using

Experimental Procedures

The experimental procedures used in the various bleaching stages and in the preparation and testing of the handsheets have been described previously (*3*). In

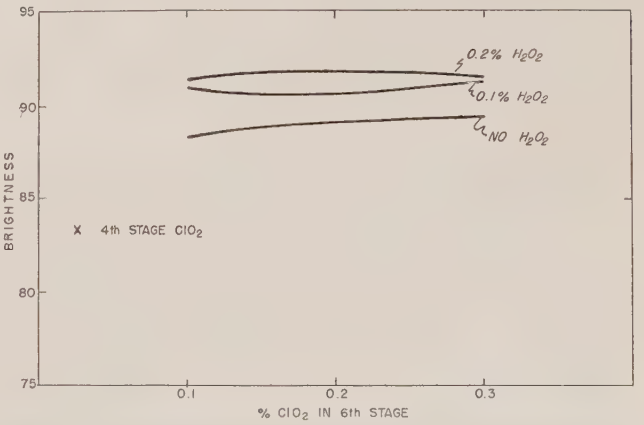


Fig. 10. Peroxide between ClO_2 stages in a 6-stage process (CEHDPD)

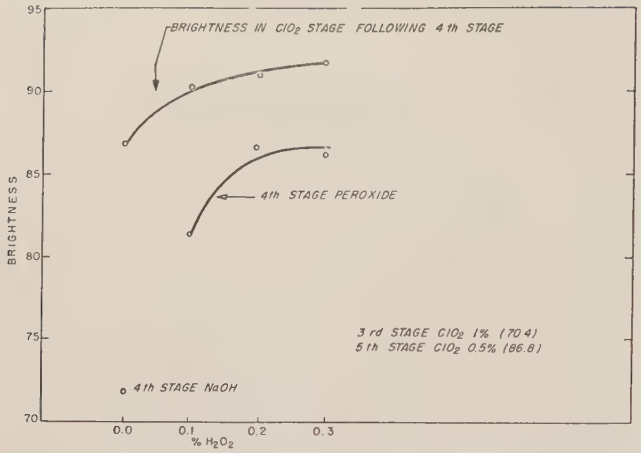


Fig. 11. Peroxide between ClO_2 stages in a 5-stage process (CEDPD)

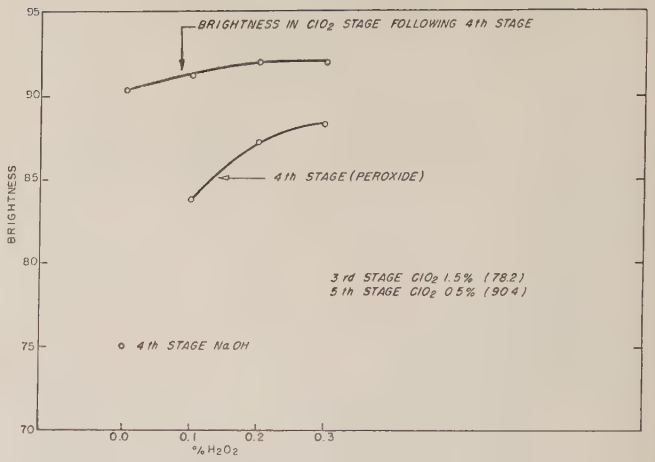


Fig. 12. Peroxide between ClO_2 stages in a 5-stage process (CEDPD)

addition to the oven-aging tests (1 hr. at 105°C.) for measuring pulp brightness stability, duplicate handsheets were subjected to aging by exposure to ultraviolet light for 30 hr. in accordance with TAPPI Routine Control Method RC-50. Duplicate handsheets were also aged for 3 hr. at 85°C. and 100% R. H. (*4*).

Bleaching Results

Peroxide After Chlorine Dioxide in a Five-Stage Process (CEHDP). The data for this process are shown in Table VII. Figure 9 shows the brightness gain for increasing amounts of peroxide applied in the final fifth stage. The bleached pulp brightness levels off around 90 with the use of 0.3% H_2O_2 for a gain of 6.5 units.

Peroxide Between Two Chlorine Dioxide Stages in a Six-Stage Process (CEHDPD). The data for this six-stage process are shown in Table VIII. Figure 10 shows the brightness gain for increasing amounts of peroxide applied in stage 5, followed by increasing amounts of ClO_2 applied in stage 6. The optimum chemical concentrations for bleaching in stages 5 and 6 are as follows: Stage 5—0.1 to 0.2% H_2O_2; Stage 6—0.2% ClO_2. The use of peroxide in stage 5 increases the brightness of sixth-stage pulp by 2 to 3 units from 89 to the 91–92 range. With peroxide between two ClO_2 stages in this six-stage system, pulp at four general levels of brightness was produced as follows: Stage 3—70; Stage 4—83; Stage 5—87–90; Stage 6—90–92.

Peroxide Between Chlorine Dioxide Stages in a Five-Stage Process (CEDPD—Total ClO_2 1.5%). The data for bleaching the jack pine kraft pulp with this process, using a total of 1.5% chlorine dioxide, are shown in Table IX. Figure 11 shows: (1) the use of 0.1 to 0.3% H_2O_2 in stage 4 increases the fifth-stage pulp brightness 3 to 5 units; (2) the optimum concentration of peroxide for application in stage 4 is 0.15 to 0.20% H_2O_2; and (3) with peroxide between two chlorine dioxide stages in this five-stage system, pulp at three general levels of brightness was produced, viz., stage 3—70, stage 4—85, stage 5—90–92.

Peroxide Between Chlorine Dioxide Stages in a Five-Stage Process (CEDPD—Total ClO_2 2.0%). The data for this process, using a total of 2.0% chlorine dioxide, are shown in Table X. Figure 12 shows: (1) the use of 0.1 to 0.3% H_2O_2 in stage 4 increased the 5th-stage pulp brightness about 1.0 to 1.5 units; (2) the optimum concentration of peroxide for application in stage 4 is 0.1 to 0.2% H_2O_2; and (3) with peroxide between two chlorine dioxide stages in this 5-stage

Table IX. Peroxide Between Chlorine Dioxide Stages in a Five-Stage Process (CEDPD—Total ClO_2 1.5%)

Stage
Unbleached. Same as Table VII.
1 and 2. Same as Table VII.
3. Chlorine dioxide: 1%—70.4; 65.1, ovendry 1 hr., 105°C.; viscosity 18.4 cp.
4 Caustic extraction: 0.3% NaOH.
4. Peroxide bleach: Used 0.1, 0.2, and 0.3% H_2O_2 as shown below.

	0.3% NaOH	*0.1% H_2O_2*	*0.2% H_2O_2*	*0.3% H_2O_2*
Brightness (airdry)	71.8	81.5	86.6	86.2
Brightness (ovendry); 1 hr., 105°C.	70.4	79.6	83.0	83.9
5. Chlorine dioxide bleach				
ClO_2 in Stage 5, %	*0.5*	*0.5*	*0.5*	*0.5*
Brightness				
Airdry	86.8	90.3	91.1	91.7
Ovendry; 1 hr., 105°C.	85.6	87.4	87.6	88.6
Ovendry; 3 hr., 85°C., 100% R.H.	83.3	84.5	86.7	87.2
Ultraviolet exposure, 30 hr.	79.1	85.6	86.4	86.6
Viscosity, cp.	18.7	18.2	17.7	17.0

Table X. Peroxide Between Chlorine Dioxide Stages in a Five-Stage Process (CEDPD—Total ClO_2 2.0%)

Stage
Unbleached. Same as Table VII.
1 and 2. Same as Table VII.
3. Chlorine dioxide: 1.5%—78.2; 71.7, ovendry 1 hr., 105°C.; viscosity 17.7 cp.
4. Caustic extraction: 0.3% NaOH.
4. Peroxide bleach: 0.1, 0.2, and 0.3% H_2O_2 as shown below

	0.3% NaOH	*0.1% H_2O_2*	*0.2% H_2O_2*	*0.3% H_2O_2*
Brightness (airdry)	75.1	83.9	87.3	88.3
Brightness (ovendry); 1 hr., 105°C.	74.1	81.2	84.8	85.8
5. Chlorine dioxide bleach				
ClO_2 in stage 5, %	*0.5*	*0.5*	*0.5*	*0.5*
Brightness				
Airdry	90.4	91.2	92.0	91.9
Ovendry; 1 hr., 105°C.	88.2	89.3	89.3	89.9
Ovendry, 3 hr., 85°C., 100% R.H.	85.4	88.0	87.8	88.0
Ultraviolet exposure, 30 hr.	84.9	86.9	85.8	87.8
Viscosity, cp.	17.1	17.0	16.4	15.1

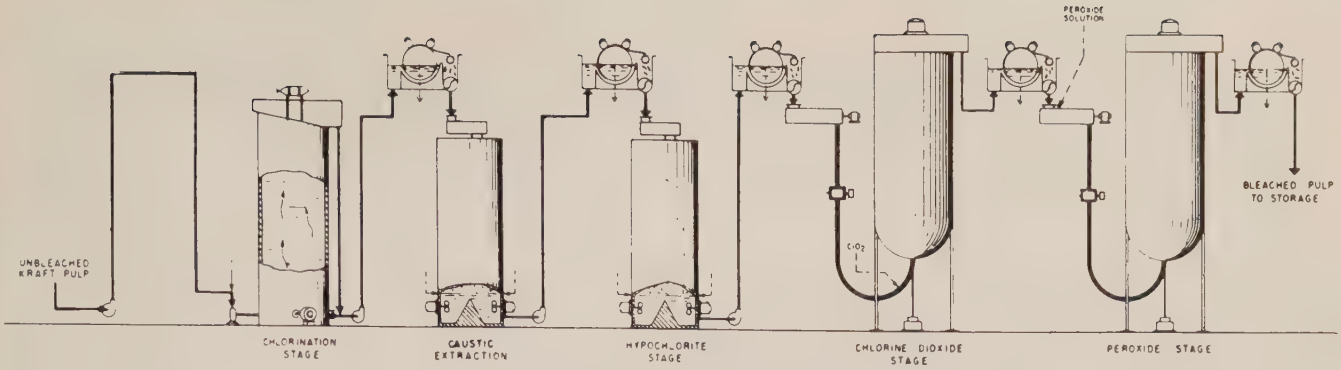


Fig. 13. Five-stage kraft bleaching process

process, pulp at three general levels of brightness was produced, viz.; stage 3—78, stage 4—85, stage 5—91–92.

Effect of Peroxide Bleaching on Kraft Pulp Viscosity. The effect of peroxide on pulp viscosity for all bleached kraft pulp reported in this laboratory series is shown in Table XI.

Table XI. Effect of Peroxide Bleaching on Kraft Pulp Viscosity

Process	H_2O_2 used, %	Before peroxide stage	After peroxide stage	Final-stage brightness	pulp, cp.
CEHD	...	..	..	83.5	17.7
CEHDP	0.05–0.30	17.7	16.2	90.0	15.8
CEHDED	...	..	..	89.1	16.8
CEHDPD	0.1–0.3	17.7	16.2	92.2	15.2
CEDED[a]	...	..	..	86.8	18.7
CEDPD[a]	0.1–0.3	18.4	17.8	91.7	17.0
CEDED[b]	...	..	..	90.4	17.1
CEDPD[b]	0.1–0.3	17.7	16.7	91.9	15.1
Average		17.9	16.7		

[a] Total ClO_2 = 1.5%.
[b] Total ClO_2 = 2.0%.

Table XII. Bleaching Conditions—Marathon Mill

Stage no.	Treatment	Time, min.	Temp., °F.	Consistency, % airdry
1	Chlorination	60	80	3
2	Caustic extraction	180	150	16
3	Calcium hypochlorite	180	90	16
4	Chlorine dioxide	240	160	14
5	Peroxide	240	185	14

Table XIII. Bleaching Southern Pine Kraft at Marathon Mill[a]

Stage no.	Chemical	% Used	Brightness	Pulp strength—400 C.S. freeness Mullen, %	Tear, %
Unbleached	...	...	..	155	205
1	Cl_2	5.0–5.5	26	..	..
2	NaOH	1.75	29	..	..
3	$Ca(OCl)_2$	0.75–1.0	65–70	..	..
4	ClO_2	0.35–0.45	82–84	..	..
5	H_2O_2[b]	0.10–0.15	86–88	150	200

[a] As reported by the mill.
[b] The H_2O_2 solution includes 0.02% Epsom salt, 2.0% sodium silicate, and 0.1 to 0.2% NaOH per moisture-free ton of pulp.

Table XIV. Bleached Kraft Pulp Consumption—Marathon Mill

Product	Tons/day
Tissue, towel, napkins	80
Food board	120
Market pulp and paper	150

Chlorine Dioxide-Peroxide Process at American Can Co. Marathon Southern Division

The new bleach plant at Naheola, Ala., is the first built specifically to use peroxide as the final stage following a chlorine dioxide bleaching treatment.

Figure 13 shows the general layout of the five-stage process—chlorination, caustic extraction, calcium hypochlorite bleach, chlorine dioxide bleach, peroxide bleach.

After an extensive research study of many processes, Marathon chose this five-stage process to produce quality pulp with favorable operating costs. The conditions employed in each stage are shown in Table XII. The bleaching performance of this mill process is given in Table XIII, and the end uses for 550 tons a day of bleached southern pine kraft at Marathon Southern mill are given in Table XIV.

CONCLUSIONS

1. Cold soda pulps can be bleached with peroxide in a refiner to 55 to 65 brightness. Under certain conditions there is a significant bleaching advantage when sulfuric acid is used for partial neutralization of the caustic-treated chips just prior to the peroxide bleaching treatment. The same pulps can be bleached to 65 to 75 brightness using peroxide in a conventional tower bleaching stage.

2. The du Pont Laboratory has developed a high-temperature groundwood bleaching process with a reaction time of 10 min. at 200°F. The brightness obtained on spruce groundwood is comparable to the results obtained in normal bleaching for one to two hours at low temperature.

3. Peroxide can be used with technical and economic advantage in five- and six-stage kraft bleaching processes operating with one or two stages of chlorine dioxide. Pulp with a 90 to 92 brightness is obtainable.

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Laboratory Bleaching of *Pinus radiata* Kraft Pulp

G. A. NICHOLLS

Unbleached pine (*Pinus radiata*) kraft pulp has been bleached by various sequences. In relation to using a three tower plant, a chlorination-alkali extraction-hypochlorite chlorination-peroxide-hypochlorite process has been examined and found to give 85 to 86 G.E. brightness pulp, the strength of which has been determined from handsheets prepared from Lampen milled stock. When bleaching by chlorination-alkali extraction-hypochlorite-chlorine dioxide it was noted that a higher hypochlorite pH led to higher ultimate brightness, and that a chlorine dioxide stage substituted for the last three stages in the above six-stage sequence gave pulp of 86 to 88 G.E. brightness with better stability to heat aging. Pulp strength has been determined and compared with that of unbleached and six-stage bleached pulps. From experiments to determine the advantage of including small amounts of chlorine dioxide with chlorine during chlorination, it has been found that viscosity gain is related to the quantity of chlorine applied.

Unbleached kraft pulp has been produced since 1953 from plantation grown *Pinus radiata* by N. Z. Forest Products Ltd. at Kinleith, which is not far north of Lake Taupo in the center of the North Island of New Zealand. Portion of this pulp has been hypochlorite bleached in Tasmania since about the same time and some associated laboratory results have already been reported (*1*). If pulp of high brightness and strength is required the necessity to use more complex multistage bleaching is well recognized.

Although there is no mystery about the multistage bleaching of pulp, there must be few mills that are identical, while there must be fewer mills where the initial aim is to produce a fully bleached pulp using three towers, and there must be practically no mills at which chlorine is over 13 c. per lb. Thus, part of this work was carried out to indicate what type of bleached pulp could be obtained from *P. radiata* using the minimum of chlorine in a three-tower plant with recirculation. This meant that the consistency, retention time, and temperature of the fourth, fifth, and sixth stages would need to be virtually the same as in the first, second, and third stages.

The problem was ultimately approached by first producing a semibleached pulp by a conventional chlorination-alkaliextraction-hypochlorite (C-E-H) sequence of stages. On the basis of what was already known (*2, 3, 4*), subsequent alkaline peroxide-hypochlorite stages in the second and third towers would be expected to give better results than alkali extraction hypochlorite stages. Thus, work was carried out using a C-E-H-P-H sequence of stages which was compared with a C-E-H-C-P-H sequence, since it would be possible to carry out a second chlorination in the first tower when semibleached pulp was being recirculated.

G. A. Nicholls, New Zealand Forest Products, Ltd., Penrose, Auckland, New Zealand.

In the above and subsequently, various stages are referred to by abbreviations, as follows:

C = chlorination
H = hypochlorite
D = chlorine dioxide
E = alkali extraction
P = peroxide

EXPERIMENTAL

Unbleached Pulp

Unbleached *P. radiata* D. Don kraft pulps were received in dry lap form from Kinleith. Laps were torn up, soaked in distilled water overnight, disintegrated in a British standard disintegrator at 3.0% stock concentration for 500 counter-revolutions, thickened, squeezed as dry as possible by hand, crumbled, mixed, sampled for moisture, and stored at 10°C.

Bleaching Procedure

In bleaching pulp according to the details given in the tables, as a general practice all pulps were diluted with water and the temperature adjusted so that after mixing in chemicals the consistency would be as stated, and the pulp suspension would be at, or quite near, the bath temperature shown. All additions of chemicals were on the basis of the ovendry weight of pulp entering stage one.

Chlorinations were carried out in stoppered glass flasks with regular shaking throughout the time specified. The other stages were carried out in polyethylene bags unless indicated otherwise, in which case a Murto rubber-lined, water-jacketed, rotating vessel with mixer was used. At consistencies of 7 or 12%, added chemicals were kneaded into the pulp.

For the chlorinations as in Tables I and III the equivalent to 100 g. ovendried wet crumbled pulp was used, but in Table V, where 20 g. pulp on an ovendried basis was taken, airdried pulp was used to maintain accuracy and was obtained from wet crumbled pulp by washing with acetone, the residual solvent being removed by an air current at 20°C.

At the end of each stage pulps were collected on hard filter paper in Buchner funnels, all pulps being washed with distilled water. After chlorination and hypochlorite stages cold water then water at 60°C. was used, whereas after alkali extraction, peroxide or chlorine dioxide the reverse procedure was followed. When a sample of pulp was withdrawn between stages to obtain test data, such as permanganate number, the whole lot of pulp was wet-crumbled and subdivided by weight, subsequent addition of chemicals taking into account the aliquot removed.

Chlorine Dioxide

Chlorine dioxide was prepared from potassium chlorate and oxalic acid at 55 to 60°C., on the basis of

Table I. C-E-H-P-H and C-E-H-C-P-H Bleaching of *P. radiata* Kraft Pulp

Column no. - *TAPPI $KMnO_4$ no.* →	*1* *14*	*2* *14*	*3* *18.5*	*4* *18.5*	*1a* *14*	*2a* *14*	*3a* *18.5*	*4a* *18.5*
Tower 1: 3.5% Consistency								
	Stage 1: Chlorination				Stage 4: Chlorination			
Time, min.	55 to 60				...	55		
Temp., °C.	25	21	20	19–21	...	20	18.5	20
Chlorine, %	4.0	3.5	4.9	4.9	...	0.50	0.30	0.30[a]
Resid. chlorine, %	0.14	0.11	0.12	0.12–0.14	...	0.36	0.11	0.05–0.08
Final pH	...	...	...	...	...	3.2	3.7	2.3–2.5
Tower 2: 12% Consistency								
	Stage 2: Alkali extraction				Stage 5: Peroxide			
Temp., °C.	70	70	70	(60)	70	70	70	70
Time, min.	60	80	85	85	70	80	85	85
Sod. hydroxide, %	1.6	1.6	2.0	1.9	0.4	0.4	0.4	0.35
Hydrogen perox., as % Na_2O_2	...	...	...	...	0.6	0.6	0.5	0.45
Epsom salts	...	...	...	...	0.12	0.12	0.12	0.10
Sod. silicate, % 41°Bé.	...	...	...	...	3.0	3.0	3.0	2.6
Final pH	10.3	10.9	10.1	9.9–10.7	10.4	10.3	10.5	10.3–10.4
Resid. peroxide, %	...	...	...	...	0.39	0.34	0.26	0.27–0.24
Brightness, G.E.	...	...	...	...	...	79.6	75.0	75.5–78.3
Tower 3: 7% Consistency								
	Stage 3: Hypochlorite				Stage 6: Hypochlorite			
Temp., °C.	35	32	31	40	40	40	40	40
Time, min.	70	110	110	110	70	110	110	110
Avail. chlorine, %	1.3	1.3	1.7	2.0	0.30	0.20	0.30	0.25
Sod. hydroxide, %	0.40	0.35	0.5	0.7–0.6	0.06	0.08	0.08	0.07–0.06
Final pH	10.4	10.3	10.3	9.9–9.4	10.4	9.9	9.4	10.0–9.8
Resid. chlorine, %	0.21	0.16	0.24	0.14–0.21	0.19	0.09	0.11	0.14–0.10
Brightness, G.E.	71.1	68.6	62.4	67.4–70.9	84.2	85.2	84.9	85.2–86.0
7 Aged, G.E.	...	...	...	...	78.3	80.0	79.6	78.7–78.7
Viscosity, cp.	...	...	...	...	99	83	129	126–99

[a] Pulps diluted with stage-1 filtrate.

a method over 100 years old (*5*), with the precaution of using analytical reagents (*6*). After scrubbing in a solution of sodium chlorite, the chlorine dioxide was absorbed in water contained in a cylinder filled with glass Raschig rings to give a solution with near 7 g.l. and up to 0.2 g. chlorine per liter, when analyzed by established procedures (*7*). Thus 0.6% (w/w) chlorine dioxide added to pulp would include up to 0.018% chlorine on pulp, which would be expected to have little significance (*8*).

Solutions of chlorine dioxide were stored at 10°C. with little or no change in strength, and calculated amounts siphoned into a pipet from which the solution was added to pulp well below the surface. For the work as in Table V, chlorine dioxide solution, diluted to approximately 4 g.p.l., was added just after the chlorine water.

Testing Methods

Brightness. Pulp was dispersed in distilled water at about 3.5% consistency on the day after bleaching, the pH adjusted to 5.0 ± 0.2 with 0.1 *N* acetic acid, and the appropriate quantity used to make handsheets for optical tests according to TAPPI Standard T 218 m-48. Handsheet brightness was determined using a Photovolt Corp. photoelectric reflection meter Model 610, fitted with a 610-W search unit, and calibrated by aid of white enamel working standards selected to have a reflectance near that of the handsheets. Aged brightnesses were determined after heating optical handsheets in an oven at 105°C. for 1 hr. without forced-air circulation.

Viscosity. Cupriethylenediamine viscosity was determined using the falling ball modification of TAPPI Standard T 230 sm-50, values being reported in centipoises for a 1% solution.

Physical Testing. Pulps were processed, in quadruplicate, in a Lampen mill, essentially according to APPITA Standard P 202 m-57, handsheets being formed according to APPITA Standard P 203m-57 and conditioned according to APPITA Standard P 415m-57. Test factors were determined according to APPITA Standard P 400 m-55, while burst factors and breaking

Table II. Comparison of Strength Properties of Unbleached and Bleached Pulps at 450 C.S.f.

	Unbleached[a]	*bleached*[a]	*Unbleached*[b]	*Bleached*[b]
Beating revolutions	11,500	10,400	13,600	10,000
Tear factor	89	89	99	91
Burst factor	74	69	80	76
Breaking length, m.	10,500	6,800	10,700	10,000

[a] C-E-H-P-H as in columns 1 and 1a, Table I.
[b] C-E-H-C-P-H as in columns 4 and 4a, Table I.

Table III. C-E-H-D Bleaching of *P. radiata* Kraft Pulp of TAPPI Permanganate No. 18.5, With Variation of pH in Hypochlorite Stage

Stage 1: 5.3% chlorine, 3.5% consistency, 60 min., 23.5–26.5°C., 0.04–0.33% residual chlorine, 35 × 110 g. oven-dry pulp		
Stage 2: 2.0% sod. hydroxide, 12% consistency, 90 min., bath at 60°C.		
Column	1	2
Final pH (average)	10.8	10.7
TAPPI $KMnO_4$ no. (average)	5.1	4.9
Stage 3: 1.2% available chlorine, 7.0% consistency, 120 min., 33–35°C., using Murto unit		
Sod. hydroxide, %	0.40	0.45
Final pH	8.8	10.5
Resid. chlorine, %	Nil	0.05
Brightness, G.E.	65.3	65.5
Stage 4: 0.60% (w/w) chlorine dioxide, 12% consistency, 240 min., bath at 70°C., 0.12% sod. hydroxide		
Final pH	4.3–4.6	4.2–4.3
Resid. ClO_2, %	0.02	0.01
Brightness, G.E.	86.4–86.8	88.7–88.3
7 Aged G.E.	81.9–82.3	84.1–85.1

Table IV. Comparison of Strength Properties of Pulps Related to Data in Table III

	Unbleached	*65 G.E.—pH 8.8*		*65 G.E.—pH 10.5*		*88 G.E.*	
C.S. freeness, ml.	450	450	720	450	720	450	723
Beating revolutions	13,600	11,200	830	11,300	900	10,600	1,200
Tear factor	99	89	169	94	168	97	165
Burst factor	80	84	50	83	50	77	50
Breaking length, m.	10,700	10,900	6,500	10,400	6,400	8,800	5,800

lengths are reported on the basis given in TAPPI Standard T 220m-53.

DISCUSSION

Five- or Six-Stage Bleach Including Peroxide

In columns 1, 1a, 2, and 2a of Table I are listed data obtained in relation to considering a C-E-H-P-H and C-E-H-C-P-H sequence of stages applied to an unbleached pulp with a TAPPI permanganate no. of 14.

Another unbleached pulp with a TAPPI permanganate no. of 18.5 was bleached using conditions as in columns 3, 3a, 4, and 4a, which are more in line with those it was anticipated might be followed in a bleaching plant. It will be seen by comparing data in columns 3 and 3a, with 4 and 4a that a stage-three brightness range of 62 to 71 G.E. gave essentially the same end result, although, admittedly, the basis for comparison is not perfect. To lower the pH the stage-four pulps, as in column 4a, were diluted with filtrate from stage one, associated experiments having already indicated that this did not seem to affect the final brightness of the pulp. The initial and aged brightness of stage six hypochlorite bleached pulps, obtained as in columns 4 and 4a, were unaltered after soaking at 4.0% consistency for 3 hr. in sulfurous acid at pH 3 to 4; however, the technique of adjusting the pH of all pulp prior to preparing brightness sheets should be noted.

With the foregoing in mind, it can be argued that, if with recirculation it is not practical to increase the somewhat short retention time in the peroxide stage relative to other stages, although it may be possible to obtain a significantly higher final brightness by, say, lowering the pH in the hypochlorite stages, this result could not be achieved without further degradation. Degradation would also arise from inclusion of a second chlorination stage without pH adjustment by the addition of acid. Concerning this it is noted that higher brightness *ex* stage three means lower chlorine consumption in stage four which results in a higher pH and greater proportion of cellulose-degrading hypochlorous acid.

Pulp strength evaluation data at 450 ml. C.S. freeness, both for pulps bleached as in columns 1, 1a, 4, and 4a of Table I, and the corresponding unbleached pulps are given in Table II. It will be seen that if strength properties are compared at the freeness stated, the overall strength values were decreased to some extent after the pulp had been bleached. In addition, while less chlorine was required to bleach the pulp cooked to a lower permanganate number, the bleached pulp derived from it had an overall strength that was below that of the other bleached pulp.

In relation to operating on six stages in the bleaching plant it is of interest that 84 to 86 G.E. pulps off the last washer have laboratory heat-aged brightnesses 3.0 G.E. higher than laboratory-bleached pulp. The reason is unknown, but may be associated with semibleached pulp being taken through the Flakt drier.

Observations on Using Chlorine Dioxide for Fourth Stage

Some results from a study involving the use of chlorine dioxide are shown in Table III. Pulps were treated by chlorination and alkali extraction under nominally identical conditions, but the hypochlorite stage was varied to give a semibleached pulp with a 65 G.E. brightness at a final pH of 8.8 and 10.5, as shown in columns 1 and 2, respectively.

In the fourth stage involving chlorine dioxide, the conditions were selected on the basis of published work (*9, 10, 11*) relating to variables affecting this type of bleaching.

It will be seen that when the hypochlorite bleached pulps were treated with 0.6% chlorine dioxide a pulp with an 88 G.E. compared with an 86 G.E. brightness, was obtained in association with the higher final pH

Table V. C(D)-E-H Bleaching of *P. radiata* Kraft Pulp With TAPPI Permanganate No. 18.5 (Acetone Washed Before Bleaching)

Column no.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Stage 1: Consistency, 3.5%; time, 60 min.; temp., 24.5–25.0°C.										
Chlorine, %	4.0	4.0	4.0	4.0	4.0	5.0	5.0	5.0	5.0	5.0
Chlorine dioxide, % (w/w)	0.00	0.05	0.10	0.20	0.40	0.00	0.05	0.10	0.20	0.40
Resid. chlorine, %	0.02	0.02	0.03	0.03	0.05	0.11	0.13	0.11	0.30	0.51
Stage 2: Consistency, 12%; time, 90 min.; bath temp., 70°C.										
Sod. hydroxide, %	1.9	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0
Final pH	10.3	10.3	10.6	10.5	10.5	10.0	10.0	10.2	10.1	10.4
TAPPI $KmNO_4$ no. (av. of 2)	5.6	5.6	5.5	5.4	5.1	4.6	4.6	4.5	4.4	4.2
Viscosity (av. of 2), cp.	274	274	276	249	207	148	200	178	152	119
Stage 3: Consistency, 7%; time, 120 min.										
Bath temp., °C.	40	40	40	40	40	35	35	35	35	35
Avail. chlorine, %	1.7	1.7	1.7	1.7	1.7	1.2	1.2	1.2	1.2	1.2
Sod. hydroxide, %	0.7	0.7	0.7	0.7	0.7	0.5	0.5	0.5	0.5	0.5
Final pH	...	10.6	10.8	10.8	10.9	10.5	10.8	10.5	10.9	11.1
Resid. chlorine, %	0.16	0.09	0.11	0.11	0.19	0.05	0.09	0.09	0.10	0.13
Brightness, G.E.	68.9	68.3	68.5	68.2	70.4	68.5	68.6	68.8	69.8	70.4
Viscosity (av. of 2), cp.	131	136	135	135	105	117	149	146	116	96

in the third stage. Presumably a higher hypochlorite pH gives some of the advantage to be expected by alkali extraction between hypochlorite and chlorine dioxide stages.

Pulp strength evaluation data at 450 ml. C.S. freeness and at 50 burst factor are given in Table IV.

If the results as in Table I and II are compared with those in Tables III and IV it will be apparent that a single chlorine dioxide stage may not only effectively replace the last three stages, as in Table I, but also lead to a pulp with an 86 to 88 G.E. initial brightness, which is two units higher, an 82 to 85 G.E. heat-aged brightness compared with 78 to 80, and physical strength properties that are at least comparable or possibly better.

Inclusion of Chlorine Dioxide in Chlorination Stage

The results in Table V were obtained from experiments to determine the advantage of including a small amount of chlorine dioxide with the chlorine in the chlorination stage, since this is known to improve viscosity (*10, 11*). It will be seen from columns 1 to 5 that the expected results were not obtained, but when the amount of chlorine in stage one was increased the expected viscosity gain was encountered, as shown in columns 6 to 10. It is noted that in spite of the much reduced viscosity after alkali extraction, as seen by comparing columns 6 to 10 with 1 to 5, the fall in viscosity of the latter group on bleaching with hypochlorite was proportionately greater than for the former. At the same time inclusion of 0.05 to 0.10% chlorine dioxide actually gave a hypochlorite bleached pulp columns 7 to 8, with a viscosity higher than that of any hypochlorite bleached pulp obtained when less chlorine was used in stage one, columns 1 to 5, irrespective of whether or not chlorine dioxide was included.

Thus, when chlorine distribution between chlorination and hypochlorite stages was 70 : 30, the inclusion of chlorine dioxide in the chlorination stage gave no viscosity increase, but when chlorine distribution was 80 : 20 the inclusion of chlorine dioxide resulted in a hypochlorite bleached pulp with increased viscosity. For increase in viscosity to result from inclusion of small amounts of chlorine dioxide in a chlorination stage, the quantity of chlorine applied in the chlorination appears to be significant.

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The Effect of Temperature and Moisture Content on the Moisture Permeability of Building Boards

Some Preliminary Results

R. D. ZIEGLER

The rate of transmission of moisture through a specimen of laminated insulation roof decking exposed to 85 and 40% R.H. on its two surfaces was measured at several different temperatures. The specimen (1-in. thick) contained a duplex paper vapor barrier, and the transmission rates almost doubled for each 10° rise in temperature between 60 and 80°F. Rates of transmission of moisture were also determined on 1/2-in. insulation sheathing and on 1/4-in. plywood specimens that had been humidified, and on specimens that had been oven-dried before the tests were started. After a steady-state had been established, the rates through the initially humidified pieces were three to six times as great as the rates through the initially oven-dried pieces. It appears that when the moisture content equilibrium is approached from the wet direction, the rate of moisture transfer is higher but when the equilibrium is approached from the dry direction the rate of transfer through the same specimen is lower. A new type of laboratory testing equipment was used which permits tests to be made under almost any relative humidity conditions and at any temperature. The tests can be continued for an unlimited length of time, so that true steady-state conditions can be established.

The rate at which moisture passes through building boards of various types is one of the fundamental properties of the boards which must be considered in many of their applications. This property is especially important when the board is used in the exterior walls of buildings that are heated during winter months. It is also important when the board is used in buildings that are dehumidified and air-conditioned during summer, and the number of these buildings is increasing steadily.

The rate of moisture transfer has been considered to be one of the constants of the board—comparable, for example, to its density or its strength. For design purposes it has been common practice to calculate the quantity of moisture that would be transferred through a board by multiplying its permeance, which is considered a constant, by the difference in the vapor pres-

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sures to which the two sides are exposed. Research workers have recognized, however, that the quantity of moisture transferred through a board is not always proportional to the vapor pressure gradient, and therefore this method of calculation is not always reliable (*1–5*). Further study must therefore be given to this important board characteristics so that it will be possible to predict with greater accuracy the quantity of moisture that will be transferred through a board under any set of conditions.

EXPERIMENTAL

Methods of Measuring the Rate of Moisture Transfer

There are several methods which are used in the laboratory to measure the rate at which moisture is transferred through boards. The most common ones are the dry-cup and wet-cup methods. In the dry-cup method the specimen is sealed as a cover over a container of desiccant, which exposes its under surface to nearly 0% R.H. In the wet-cup method the specimen is sealed as a cover over a container of water which exposes its under surface to almost 100% R.H. The assembled cups are placed in an atmosphere of 50% R.H. to establish a humidity gradient across the specimen of about 50% for both the dry-cup and wet-cup methods. If desired, the assembled cups could be placed in an atmosphere controlled at some humidity other than 50% to establish other humidity gradients across the specimens, but when this is done, one surface would still be exposed to either 0 or 100% R.H. In any case, the assembled unit is weighed periodically and the gain in weight for the dry cup, or the loss in weight for the wet cup per unit time is a measure of the rate of transfer of moisture through the test specimen. These procedures are limited in the range of relative humidities to which the two sides of the specimen can be exposed.

Professor Joy of Pennsylvania State University and his associates have developed the Penn State-Armstrong cell for laboratory measurement of the water vapor transmission rates through building materials (*9*). In this cell, a specimen 12 in. in diameter is placed in a horizontal position between two chambers. The relative humidity is different in each chamber to establish a humidity gradient and vapor pressure gradient across the specimen. In one design of the cell the relative humidities can be set to any chosen value by means of electronic controllers which are activated by electric hygrometer sensing elements within the chambers. The moisture absorbing material in the lower humidity chamber and the moisture-supplying material in the higher humidity chamber are both supported by calibrated springs. The increase in weight of the absorbing material and the loss in weight of the moisture supplying material are both determined by measuring the deflections of the calibrated springs. These weights can be determined to the nearest $^1/_4$ grain, or 0.016 g.

A testing device in use at the National Bureau of Standards determines the rate of transfer of moisture as well as of heat through a specimen 4 by 8 ft. (*7*). The humidities on the two surfaces are controlled by Dunmore-type sensing elements and can be set at any desired value. The moisture entering the panel on the high-humidity side is determined by noting the weight changes of a pan of water placed on a cantilever scale. The silica gel absorbent on the dry side is also weighed periodically.

The U. S. Naval Civil Engineering Research and Evaluation Laboratory at Port Hueneme, Calif., determines the rate of transfer of moisture through composite wall specimens 6 by 7 ft., and is used primarily for testing such materials as concrete block and brick. The temperature and humidities to which the two surfaces of the specimen are exposed are maintained at desired values by the use of electronic controllers (*8*).

Washington State University Method of Measuring the Rate of Moisture Transfer

A new method which measures the quantity of moisture transferred through a specimen to the nearest tenth of a milligram and which permits tests to be made under a wide range of relative humidity conditions has been developed at Washington State University. A complete description of it is contained in a previous report (*6*). In general, the method utilizes two metal pans which are bolted together through edge flanges, with the test specimen sandwiched in a horizontal position between them. This forms two enclosed chambers which are 12-in. square and 2-in. deep and which are separated by the specimen. The relative humidity in each chamber is maintained at a different value by means of saturated salt solutions to establish a relative humidity difference, and consequently a vapor pressure difference across the test piece. This forces moisture to pass through the specimen from the chamber below, which has the higher humidity, into the chamber above, which has the lower humidity. The moisture passing into the chamber above the specimen is absorbed by the saturated salt solution.

The moisture-absorbing solution is contained in four small plastic dishes. The top chamber of the tester is equipped with a covered access port and the dishes of absorbent are removed from the top chamber periodically through the access port, weighed on an analytical balance, and returned again to the chamber. Their weights can, therefore, be determined to a tenth of a milligram. The rate of transfer of moisture through the specimen is calculated from the increase in the weight of the moisture-absorbing solution during a measured time of exposure.

The salt solution used as the moisture absorbent is one which has been thickened by the addition of excess salt to a wet mass of undissolved salt crystals. The absorbing solution is therefore present on this mixture as a thin layer surrounding the undissolved salt crystals. In this thickened form the solution is placed on a raised false bottom in the plastic container and the moisture it absorbs during the test flows over the surface of the mixture to the under side of the false bottom. As the liquid flows over the mixture, it dissolves enough of the salt crystals to maintain it as a saturated solution. In this manner, the thin layer of absorbing solution remains saturated and maintains its full moisture absorbing ability even though it absorbs a considerable amount of moisture.

The containers of the thickened absorbing solution are closed with tight-fitting covers while they are outside of the tester to prevent exchange of moisture with the surrounding air. Household, plastic soap boxes

have been found to be very good absorbent containers. They are light in weight, have good covers, and are not corroded by the salt solution. The soap boxes can also be obtained in a variety of colors for easy identification.

The advantages of this testing method can be listed as follows:

1. The specimen can be tested using any relative humidity on each of its two sides that can be established by saturated salt solutions. This permits tests to be made under conditions that approach those to which the specimens will be subjected in service.
2. The moisture actually transferred can be weighed to a tenth of a milligram, which is greater accuracy than obtained by other methods.
3. Since the moisture transferred can be weighed to greater accuracy, reliable data can be obtained for materials having a very low rate of transfer, and also under test conditions permitting a low rate of transfer through the material.
4. The moisture absorbent can be replaced when necessary. Therefore, the test can be continued for as long a time as may be required to establish a true steady-state condition.
5. Since the moisture absorbent can be replaced when necessary, accurate test data can be obtained on specimens and under testing conditions where high rates of moisture transfer prevail. The moisture absorbing material can be replaced in these tests before it becomes too wet and loses its absorbing ability.
6. The test area of the specimen is 12-in. square, which is larger than the test area in the commonly used cup methods.
7. The specimen is clamped rigidly in place so that it cannot warp during a test.

STUDIES OF MOISTURE TRANSMISSION CHARACTERISTICS OF BOARDS

Effect of Temperature

The Washington State University testing method was used to study the effect of temperature on the rate at which moisture passes through a specimen of laminated insulation roof decking when exposed to 85 and 40% R.H. on its two surfaces. The specimen had been reduced to a thickness of 1 in., so that it consisted of two $^1/_2$-in. insulation boards bonded together with a duplex paper vapor barrier between them. The same specimen was tested at several different temperatures within the range of 57 to 84°F. Both sides were exposed to the same temperature in all cases.

The results obtained are shown in Table I and are plotted in Fig. 1. Under these conditions an increase in temperature markedly increased the rate of moisture transmission through the roof decking. Transmission rates taken from the curve at 60, 70, and 80°F. in grams per 24 hr. and also in grains per sq. ft. per hr. per in. of mercury vapor pressure difference are listed in the following table:

Temperature, °F.	*Moisture transmission, g. per 24 hr.*	*Grains/sq. ft./hr./ in. Hg V.P. diff.*
60	0.195	0.50
70	0.375	0.72
80	0.700	0.94

Table I. Moisture Transmission Rates at Different Temperatures

Roof decking specimen 1-in. thick with a duplex paper vapor barrier. Relative humidites on the two sides of the specimen = 85 and 40%

Temperature,, °F.	*G./sq. ft./ 24 hr.*	*Grains/sq. ft./hr./ in. Hg V. P. diff.*
57.0	0.163	0.47
61.0	0.200	0.50
62.2	0.213	0.51
66.0	0.317	0.66
69.5	0.392	0.72
80.0	0.714	0.93
83.0	0.883	1.00
84.5	0.881	1.00

A study of this table shows that the rate of moisture transmission in grams per 24 hr. almost doubles for each 10° rise in temperature between 60 and 80°F. This can be accounted for, in part, by the increase in vapor pressure difference with rising temperature. As the table shows, however, the moisture transmission in grains per square foot per hour per inch of mercury vapor pressure differences also increases with increasing temperature. Therefore, when tested under high relative humidity conditions at different temperatures, the rate of moisture transmission is not proportional to the vapor pressure difference, because if it were, the transmission rates per inch of mercury vapor pressure differences would be the same at each temperature.

An important conclusion is that when making a determination of the rate of moisture transmission on insulation board in the laboratory, it is very important not to permit the temperature to vary, since a comparatively small variation in temperature causes a wide variation in test results. It is desirable that the temperature

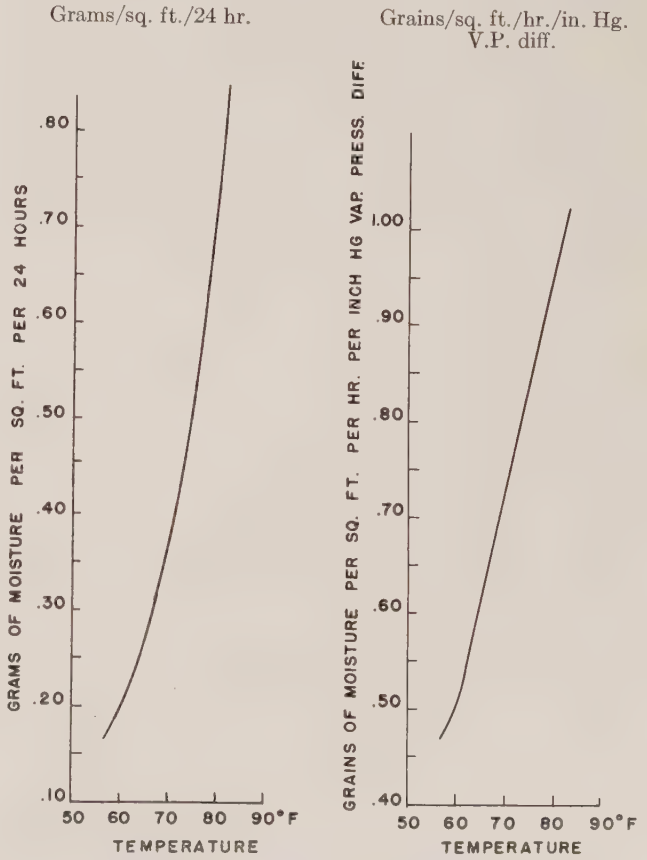

Fig. 1. Moisture transmission rates at different temperatures

Table II

Test no.	Material	Treatment before the test	Relative humidity gradient, %	Permeance, grains/hr. sq. ft./ in. Hg.
1	Insulation roof decking, 1-in. thick	a. Oven-dried	32	0.60
		b. Wetted to 25% H_2O	32	0.65
2	Insulation board sheathing, 1/2-in.	a. Oven-dried	46	1.8
		b. Humidified to 14.8% H_2O	44	5.4
3	Plywood with one surface finished, 1/4-in.	a. Oven-heated 5 min.	45	0.85
		b. Same piece humidified	45	2.33
		c. Same piece redried	45	0.97
4	Plywood with one surface finished, 1/4-in.	a. Oven-heated 5 min.	45	0.85
		b. Same piece wetted to 25% H_2O	44	3.0
5	Exterior plywood unfinished, 1/4-in.	a. Oven-dried	46	1.64
		b. Humidified to 16.9% H_2O	44	10.3

Notes:
1. R.H. on the wetter side was 85% in all cases, and was produced by a saturated KCl solution.
2. R.H. on the drier side for test no. 1 was 53%, produced by a saturated $Mg(NO_3)_2$ solution.
3. R.H. on the drier side for tests nos. 2–5 was about 40%, produced by a saturated $Zn(NO_3)_2$ solution.
4. Temperatures = 70°F. in most cases.

variation during a test be limited to $\pm 1/4$°F. which will limit the dispersion of results to ±3%.

Effect of the Initial Moisture Content of a Test Specimen on its Rate of Moisture Transmission

The Washington State University testing method was used to study the effect of the initial moisture content of the specimen on its rate of moisture transmission. Tests were made on insulation board and plywood specimens that had been oven-dried and on specimens that had been oven-dried and then re-humidified or re-wetted just before testing, to a level well above the equilibrium moisture content corresponding to the test conditions. The testing conditions were the same for both oven-dried and humidified pieces.

Results obtained with several different types of board materials are shown in Table II. The values reported are those that were obtained after steady-state conditions had been established. A study of Table II shows the importance of the moisture content of the

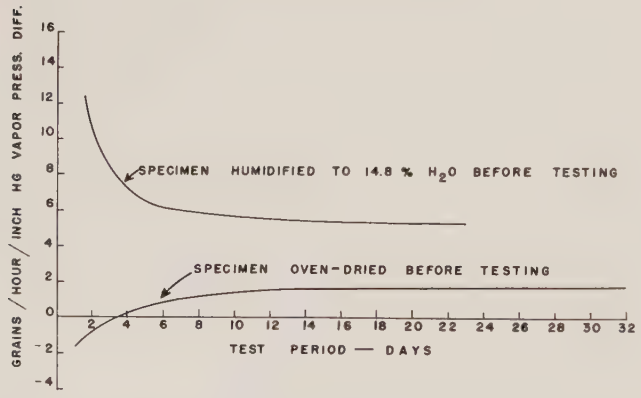
GRAINS / HOUR / INCH HG VAPOR PRESS. DIFF.
SPECIMEN HUMIDIFIED TO 14.8 % H2O BEFORE TESTING
SPECIMEN OVEN-DRIED BEFORE TESTING
TEST PERIOD — DAYS

Fig. 2. Rate of moisture transmission through 1/2-in. insulation board sheathing

specimen on the rate at which moisture passes through when steady-state conditions have been established. Test number 1, on the 1-in. thick laminated insulation roof decking containing a duplex paper vapor barrier shows practically no difference between the initially oven-dried and initially humidified specimens.

In test number 2, on 1/2-in. asphalt impregnated and

Table III. Absorbed Moisture Content of Specimens at the Beginning and at the End of Moisture Transmission Tests

Test no.	Material	Initial conditions	Absorbed moisture content of the specimens — Beginning of test — g.	Beginning of test — %	End of test — g.	End of test — %
2	Insulation sheathing, 1/4 in.	Oven-dried		0	39	8.7
		Humidified	65	14.8	47	10.7
5	Exterior plywood, 1/4-in.	Oven-dried		0	49	12.8
		Humidified	65	16.9	57	14.6

coated fiber board sheathing the rate of transfer through the initially humidified specimen was 5.4 grains per hr. per sq. ft. which is about three times as great as the rate of 1.8 grains per hr. per sq. ft. which was attained on the initially ovendry specimen.

Test number 3 was made on one specimen of 1/4-in. plywood which had been finished on one side. The specimen was first placed in the tester in the dry condition, and the rate of moisture transfer was found to be 0.85 grains per hr. per sq. ft. per in. of mercury vapor pressure difference. It was then removed from the tester and placed in a humidity cabinet until its moisture content was approximately 19% and was reassembled in the tester. In this condition, the steady-state rate of transfer was 2.33 grains, almost a threefold increase.

To determine whether the humidification had permanently affected the rate of transfer of moisture through the material, the specimen in test number 3, after being tested in the humidified condition, was removed from the tester, re-dried in the oven, and re-tested. As Table I shows, the rate of transfer after redrying was 0.97 grains per hour per sq. ft. per in. of mercury vapor pressure difference which is very close to the 0.85 grains obtained before it had been humidified. Therefore, the humidification did not permanently affect the rate of transfer. This would indicate that the value obtained depends upon whether the specimen approaches equilibrium under test conditions from the wet or dry side.

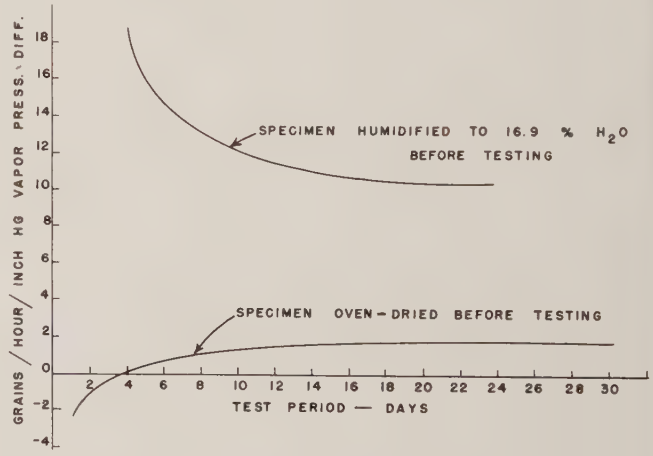
GRAINS / HOUR / INCH HG VAPOR PRESS. DIFF.
SPECIMEN HUMIDIFIED TO 16.9 % H2O BEFORE TESTING
SPECIMEN OVEN-DRIED BEFORE TESTING
TEST PERIOD — DAYS

Fig. 3. Rate of moisture transmission through 1/4-in. exterior plywood

Test number 4 was also made on one specimen of 1/4-in. plywood which had been finished on one side. It was tested in the dry condition first, giving a value of 0.85 grains, which is the same as that obtained in number 3. It was then removed from the tester and was placed in contact with wet blotting paper until it had absorbed approximately 25% moisture, and was

reassembled in the tester. In this condition the steady-state rate of transfer through the same piece was 3.0 grains per sq. ft. per hr. per in. of mercury vapor pressure difference, which is more than three times its rate when it was dry.

Test number 5 was made on two separate pieces of unfinished 1/4-in. exterior grade plywood taken from adjacent areas of the original piece. The rate of transfer of moisture through the specimen that was humidified before the test was 10.3 grains per hr. per sq. ft., which is more than six times as great as the value of 1.64 grains per hr. per sq. ft. which was obtained on the specimen that was oven-dried before the test.

The rates of moisture transmission that were obtained each day on the humidified and oven-dried specimens are plotted in Fig. 2 for the 1/2-in. insulation sheathing, and in Fig. 3 for the 1/4-in. plywood. For the humidified specimens the rates were high at the beginning for both materials because they include moisture that is escaping from the specimens. As the equilibrium moisture content becomes established during the tests, the specimens stop losing moisture, and their rates of moisture transmission taper off to values which remain constant.

For the oven-dried specimens, the rates of moisture transfer appear to be negative at the beginning for both materials. This is because the specimens are absorbing moisture from both upper and lower chambers of the apparatus at the beginning of the test to come up to their equilibrium values. This moisture is being taken from the saturated salt solutions which causes them to lose weight. The loss in weight makes it appear that the rates of vapor transmission at the beginning of the test are negative. The specimens stop absorbing moisture when they have attained equilibrium with the exposure atmospheres, and the rates of moisture transmission have then tapered off to values which remain constant.

Table III shows the total moisture present in initially humidified and initially oven-dried specimens when the tests were started and again when they were discontinued after steady-state conditions had been established. For the humidified insulation sheathing specimen, the moisture content decreased from 65 to 47 g. while it was being tested, which is a loss of 18 g. During the test, a total of 85 g. of moisture had permeated through the specimen and when the test was stopped, moisture was continuing to pass through at the rate of 3.2 g. per 24 hr. For the humidified plywood specimen the moisture content decreased from 65 to 57 g. while it was being tested, which is a loss of 8 g. During the test a total of 145 g. of moisture had permeated through the specimen and when the test was stopped moisture was continuing to pass through at the rate of 5.4 g. per 24 hr. The total moisture collected on the dry side of the specimen during both tests was considerably greater than the loss in specimen weights due to a lowering of their absorbed moisture contents. Also the moisture transmission rates had become constant. Therefore, the high rates of moisture transmission obtained on the humidified boards after steady-state conditions had been established were not caused by escaping excess moisture.

Therefore, when vapor transmission tests are being made on specimens which consist, at least partly, of hygroscopic materials, it is important to allow the board to attain its equilibrium moisture content before test data are taken. Figures 2 and 3 show that several days may be required to establish this equilibrium moisture content and attain the constant rates of moisture transfer. The time required to reach steady-state conditions depends, of course, on the thickness, weight, and permeability of the specimens.

CONCLUSIONS AND RECOMMENDATIONS

1. The rate of moisture transmission through an insulation roof decking containing a duplex paper vapor barrier, when exposed to humidities approaching 85%, increases rapidly with increasing temperature. If material of this type is used in building constructions where it may be exposed to high relative humidity and high temperatures, some difficulties may arise due to an excessive transfer of moisture.

2. The rate of transfer of moisture through some board materials has been shown to be lower if the equilibrium moisture content is approached from the dry side. Conversely, the rate of transmission is higher if the equilibrium moisture content is approached from the wet side. Therefore, to reduce moisture transmission through a board, its content of absorbed moisture just be kept low. This indicates that the board should be well-sized because the absorbed moisture content of a well-sized board will generally be lower than that of a poorly sized board. Further experimental work should be done on boards that are sized to different degrees to determine the effect of this factor on the rates of moisture transmission.

3. Since a high content of absorbed moisture in a board will cause moisture to transfer through it readily, it seems reasonable to assume that any adhesive used in the board should also be one that does not absorb moisture.

4. Values of the rates of water vapor transmission through a board, as reported in the literature, may differ widely for the same material. It is understandable that various results would be obtained by different workers since there are so many variables that affect the test results. Two of the variables, as reported in this paper, are the moisture content of the specimen when a test is started, and the temperature at which a test is made. For hygroscopic materials, it would be desirable to include in the standard testing procedures a standard method of conditioning the specimen before it is tested. In this way, the different specimens would arrive at the same moisture gradient during the test and this should be helpful in reducing the test variations that are obtained.

5. Boards should be tested under conditions that are as close as possible to those the board will meet in service.

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Differential Speed Measurement

ROBERT A. WALCH

This article covers the design and evaluation of a highly sensitive electronic differential speed recording system for paper machine drier sections. The system was developed by the Green Bay Paper & Pulp Co. as an aid to overcome some unique operating problems which are described. A step-by-step account of the predesign work and the logic behind the final design is given. Operating principles of the final design, which has been in service since 1957, are explained and illustrated. An evaluation section is based on field experience with the equipment and offers chart records for the reader's inspection. It is concluded this venture was highly successful and has more than satisfied the conditions upon which the project was justified.

Since the origin of Green Bay Paper & Pulp Co. in 1949, the ability to accurately set and reproduce speed differentials between drier sections has been a necessary requirement for efficient operation. While the desirability of such techniques undoubtedly exists in many paper mills, the need is probably more acute at Green Bay because of some unique operating circumstances.

Green Bay Paper & Pulp Co. operates one 161-in. trim fourdrinier, manufacturing neutral sulfite semichemical corrugating board in grades from 20 to 40 lb. per 1000 sq. ft. at speeds up to 1000 f.p.m. The various sections of the machine are driven from a turbine powered line shaft via Bagley and Sewall simplex drives and variable pitch shives. The various sections of driers operate without the use of drier felts, depending on precise draw differences to carry the sheet tightly against the 60-in. driers to give good drying rates. Excessive draw differences, while giving good heat transfer rates, result in an abnormal amount of break time. Sloppy draws can result in paper machine speed reductions of 10 to 20% due to inefficient use of the 54 driers. Excessive draws in the wet end press sections can result in both wet end breaks and quality degradation of corrugating board. As the speed differentials between some sections are very small (often less than 3 f.p.m.), it is impossible for a machine tender to always obtain optimum draw settings by the normal physical senses of touch and sight.

After six years of operation with no speed measuring aids, other than hand tachometers or usually the machine tender's judgment as to what constituted proper draws, it was decided to install a suitable speed measuring system. It was not the object of the proposed system to replace the judgment of the operators, but rather to act as a tool for them to use in performing their job. The justification of such a system was based on the following;

1. Increased machine efficiency. That meant higher machine speeds paralleled with less break time.
2. Improvement of quality by utilizing optimum draws in the press sections.
3. Reduction of unscheduled machine down time due to mechanical problems in the drive sections. This can frequently be detected as a draw variation long before complete failure occurs. Knowledge of such a condition permits repair during scheduled down time.

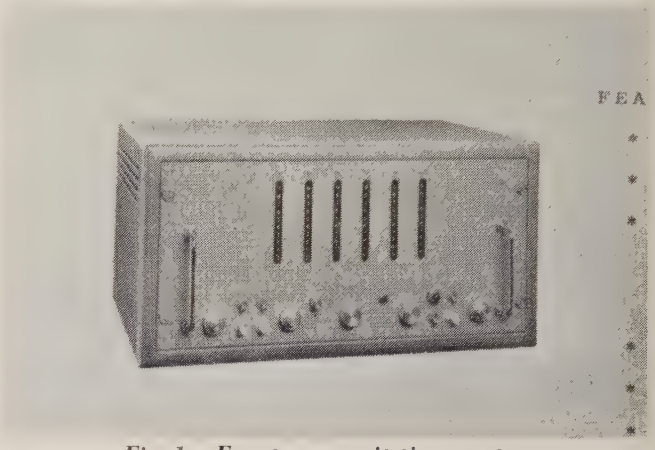

Fig. 1. Events per unit time meter

4. Facilitate faster start-ups and grade changes.

It was felt this system, to be of the maximum utility, should be one which recorded data on a strip chart in a form that would make it easy to detect variations or draw changes in the order of 0.5 f.p.m.

DESIGN

A preliminary study was made of the paper machine to determine the range of differentials being dealt with. Initial testing was done with a hand tachometer followed with more precise measurements made with a stroboscope. It was found at the wet end, draws

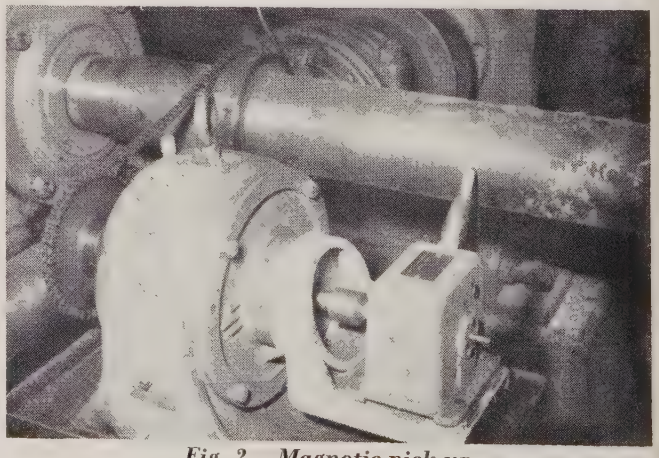

Fig. 2. Magnetic pick up

Robert A. Walch, Technical Engineer, Green Bay Paper & Pulp Co., Green Bay, Wis.

of 10 to 12 f.p.m. were common, while at the dry end, draw differences were frequently as little as 0.5 f.p.m.

A survey of instrument companies, normally supplying the paper industry, indicated the accuracy required could not be obtained with an off-the-shelf package system. Conventional tachometry available at that time was expected to give a nominal 1% accuracy (10 f.p.m. at 1000 f.p.m.) which, in some cases, exceeded the differentials to be measured many fold.

At this point, it appeared desirable to investigate digital measuring equipment which boasted a theoretical accuracy of 1 p.p.m. in its ability to measure. A single six decade EPUT (Events Per Unit Time) meter and magnetic pickup was brought into the mill for evaluation.

The results were very encouraging regarding the equipment as well as pointing up some important considerations which influenced the final design.

For those who are not familiar with the forementioned equipment, an explanation is in order. The six decade EPUT meter is an electronic counting device (Fig. 1) which will receive electrical impulses and totalize them. It has a crystal controlled time base which will allow the unit to receive impulses for an exact preset time interval. The pickup referred to is an impulse generator (Fig. 2). A soft iron wheel, with a number of teeth cut around its circumference making it resemble a gear, rotates freely on ball bearings. Mounted perpendicular to a tangent of the wheel and about 0.002 in. away is a magnetic probe. Each time a tooth of the rotating element passes the probe an impulse is generated having a voltage in the range of 0.5 to 2 v., depending on the air gap between the probe and wheel. This generates a sine wave which is relatively clean. If the pickup wheel is driven by a rotating shaft and the signal fed to an EPUT meter, the number of impulses generated per unit of time will appear in digital form on the EPUT meter and will be a function of the shaft speed. If the relationship between the rotating element and the pickup wheel are of given mathematical ratios, the device will read out directly in shaft revolutions per minute. When this speed measuring method is applied to a shaft driving a drier, the gear ratio driving the pickup and the number of teeth on the impulse wheel can be selected to give the peripheral speed of the drier. Theoretically, such a system can measure machine speed to ±0.01 f.p.m. at 1000 f.p.m.

After obtaining data from various machine sections, as well as the line shaft, it was apparent the proposed system should measure differential speeds rather than record absolute numerical values. It was found the line shaft of the paper machine would vary in revolutions per minute causing all drier sections to surge up and down slightly. This was normal operation and did not hurt a thing. As a matter of fact, it was never known this condition existed. Unfortunately, such a condition would make a chart record difficult to interpret if the absolute speed were recorded and all sections were swinging more than some of the draw differences! Furthermore, EPUT meters on each of the machine sections would be taking spot measurements at different time intervals. Combine this with an over-all surge in line shaft speed and the indicated effect would be that of changing draws when actually all machine sections would be varying slightly in absolute speed in unison. Thus, it appeared desirable to design out absolute speed and work on a differential basis.

After putting this much work into the project, new considerations made it questionable if even an absolute differential speed measuring system was desirable from the operator's point of view.

Now consider how draw requirements may vary on a machine operating at different speeds. It was felt that in the manufacture of corrugating board optimum draw between sections could be defined as the amount of tolerable stretch per unit length of paper. As an

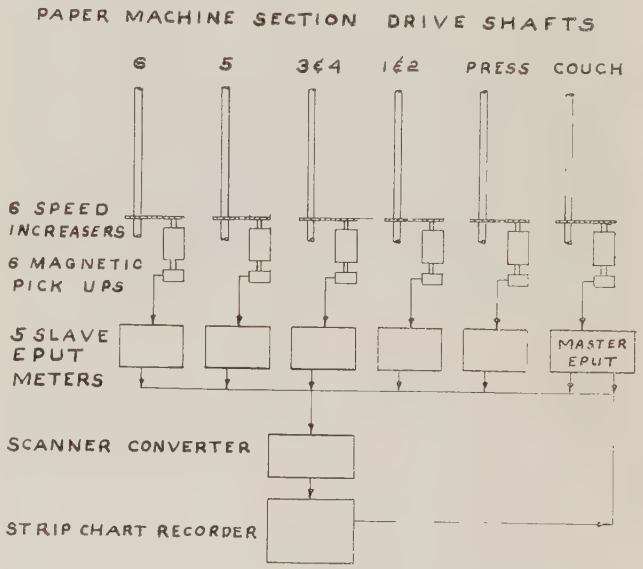

Fig. 3. Schematic arrangement of components

example, consider a hypothetical paper machine driven by a line shaft where one section is going 1000 f.p.m. and the next 1200 f.p.m. The absolute speed difference is 200 f.p.m. and the percentage difference is 20%. Now reduce the speed of this machine in half by slowing down the line shaft. The fast section is now going 600 f.p.m. and the slow one 500 f.p.m. The absolute speed difference is now only 100 f.p.m. but the percentage difference is still 20%. If paper passing over this hypothetical machine required a draw of 200 ft. per 1000 ft. of travel or 20%, the correct draw would exist at both speeds cited in the above example. The absolute speed difference between sections was reduced radically when the machine was slowed down but the percentage difference between one section and the other remained constant.

While recording absolute speed differentials would be a method of presenting data, it would undoubtedly be confusing to a machine tender who thinks in terms of draw being constant and proper or changing and becoming an improper setting. If the machine were slowed down and the record of draw showed a decrease without adjustment of draw controls, the speed recording device would probably not be considered a good operating tool. Based on the above, it was decided to design out this undesirable feature and arrive at a system that would show relative speed differences, or a constant amount of stretch between sections regardless of machine speed changes or line shaft varia-

tions which would cause all sections to change speed in a like manner. Thus, the basis of design was finalized. The use of digital equipment would lend itself very nicely to the application.

In the final design (see Fig. 3) magnetic pickups were connected to the in-shafts of one press section, the couch, and four drier sections. These units are chain driven via mechanical speed increasers. Impulse wheels and sprocket ratios were selected so when all sections of the paper machine are traveling at 1000 f.p.m., the period for all pulse generators to produce 10,000 pulses is mathematically calculated to be 1.237164 sec.

The signal from each pickup is fed to a modified EPUT meter which has had the crystal time base removed. The pickup and EPUT meter connected to the couch section are used as a time base for the entire measuring system. During the exact period the couch pickup generates 10,000 pulses, the companion EPUT unit allows a slave EPUT meter on each other section to receive pulses from its pickup. As the couch is the slowest section of the machine, all slave EPUTS receive more pulses than the base EPUT in proportion to the differential speed being measured as referred to the couch roll. Thus, if the couch is going 1000 f.p.m. and the second press is traveling 20.2 f.p.m. faster, the press EPUT will read 10202. If the third drier is going 30.1 f.p.m. faster than the couch, its EPUT meter will read 10301. Note that the last three significant figures represent feet per minute speed difference when the couch is going 1000 f.p.m. At any other speed they represent the per cent difference from couch to section in question. This percentage read out holds at all machine speeds as the couch EPUT always counts for 10,000 pulses during which time the slave EPUT meters of other sections receive pulses in proportion to their section speeds. As all EPUTS count during the same period, they cancel out any effect of line shaft speed variation which would effect all sections in a like manner.

To facilitate presentation of data after the measurement sequence, the last three significant figures are fed through an analog converter and transcribed on a multipoint strip chart recorder. When the last point is printed on the recorder, it resets the master counter which in turn will take another set of readings. The limiting factor in the frequency of measurement is the print out time which requires 2 sec. per point. Thus, a complete set of section speeds are recorded approximately each 14 sec.

Additional features which were added to this system to increase its flexibility are as follows:

1. The option to use a 10,000 or a 100,000 pulse base period of measurement. When the selector switch is changed from the 10,000 base to the 100,000 base, it automatically switches the analog pickup one decade to the left on the EPUT meters. This is so the third, fourth, and fifth significant figures of the EPUT meters (which are then counting to six significant figures) will still be the ones transcribed on the strip chart.

2. A variable range is provided for the strip chart recorder to allow full scale to represent as little as 1% of the couch speed or as much as 10% of the couch speed or any amount of suppression in between. This was done to allow maximum flexibility in presenting section speed data in the most readable form.

3. A calibration device has been provided which allows preset test numbers to be fed into the analog converter in place of the EPUT meter signal. This is used for calibrating the strip chart recorder to any range which is desired as well as for varifying the accuracy of the digital to analog conversion.

4. A multiple speed chart drive consisting of a high and low range was provided for the recorder.

Fig. 4. The system as installed

The expected total maximum theoretical error of the system is shown by the following computation which is based on manufacturers' accuracy estimates for the components:

The operating conditions are:

1. Pulse base—10,000.
2. Couch speed—1000 f.p.m.
3. Recorder range—0 to 5% couch speed equal to full scale.

	F.p.m.
Error of EPUT meter ±1 part in 10,000	0.1
Maximum error introduced by analog conversion 50.0 (±0.35%)	0.175
Recorder repeatability of $^1/_4$% of full scale 50.0 × $^1/_4$%	0.125
Maximum error to be no more than ±0.400 f.p.m.	
At a scale range of 2.5% this composite error would be reduced to ±0.24 f.p.m.	

This system as described was placed in operation during September 1957 (see Fig. 4).

EVALUATION

Maintenance

The first general reaction to seeing this speed measuring system is that it is unduly complicated. In some respects this is true, however, practically, its complex

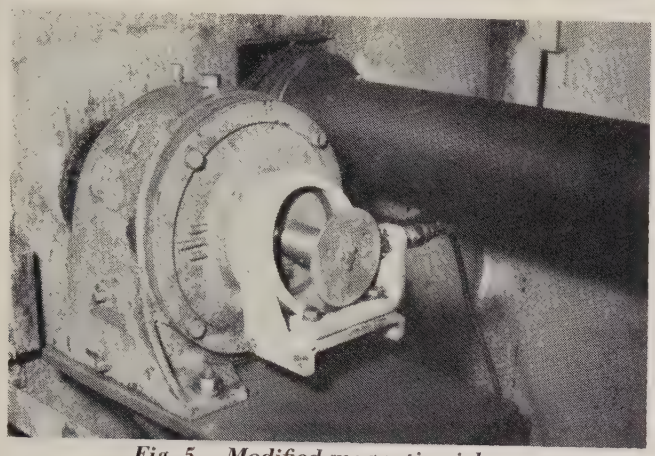

Fig. 5. Modified magnetic pick up

appearance has not proved to be any handicap. Basically, it is a system of parallel units, each relatively simple and basic by the standards of the electronic industry.

The magnetic pickups have been explained. They are the utmost in simplicity. Initially, some bearing trouble was experienced. As bearings failed, the tachometers have been rebuilt as modified units (Fig. 5) where the impulse wheels are connected directly to the mechanical speed increasers which are extremely rugged. No failures of these modified units have occurred.

A view of the main cubical looks rather complex. However, it consists of five slave EPUT meters which are all duplicates, one master counter for the couch section which is similar to the slaves, and the scanner converter section which consists of an analog converter, sequence controls and calibration devices (Fig. 6).

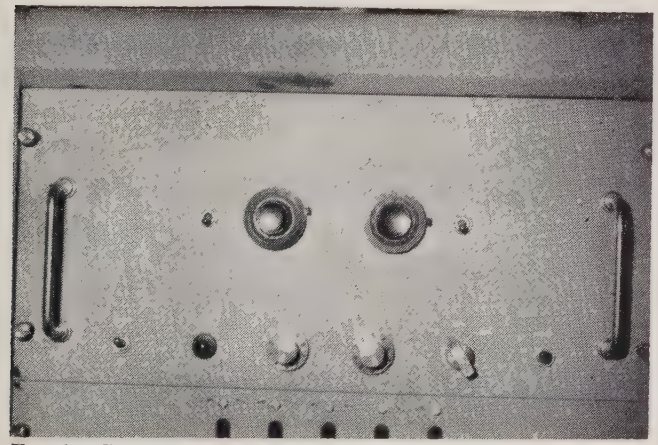

Fig. 6. Scanner converter also houses chart range and calibration controls

Each unit is rack mounted and slips out forward for service. Mounted on top is a standard multipoint strip chart recorder.

The entire system contains approximately 130 vacuum tubes. The manufacturer described its reliability and frequency of repair as paralleling a home radio—not as complex or troublesome as a modern TV set. While that statement probably oversells this type of equipment, the system has not been particularly troublesome. During the first three months there were quite a few tube failures and some relay trouble. Since then maintenance has been very limited. Blanket tube replacements are not made on this equipment but rather changes are made only upon

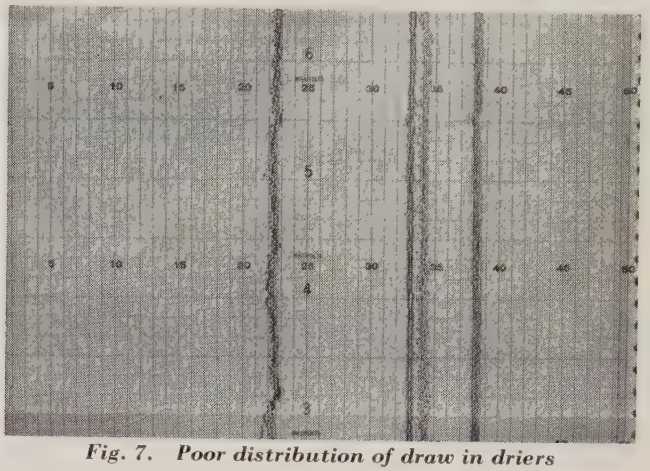

Fig. 7. Poor distribution of draw in driers

failure. It is estimated the instrument department spends 2 or 3 hr. per month servicing this equipment. Anyone familiar with industrial electronics would find it easy to service and could locate trouble in a matter of minutes.

Process Utility

When the system was put into operation, it was not presented to the operating personnel on a "here it is, do what it says" basis, but rather they were asked to just observe the records to note what was occurring throughout the paper machine. After a few weeks it was suggested they use the records in touching up their

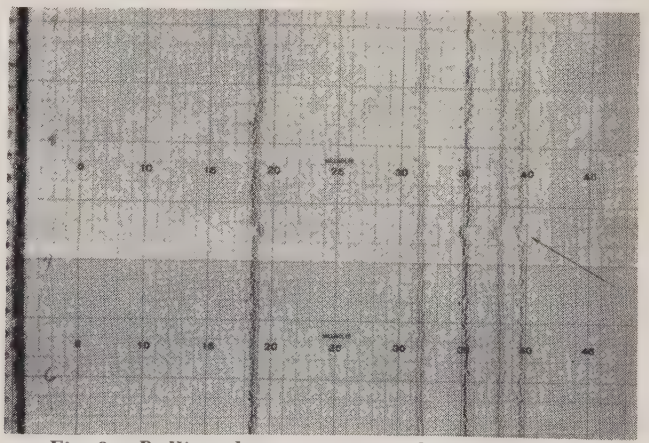

Fig. 8. Pulling three sections with calender stack

Note: Speed decreases on break.

operations if they felt this system could be helpful. During paper machine start-ups members of the technical staff were present to observe how the system functioned and to aid personnel in interpreting its readings.

Undesirable operating conditions which were pointed up by the new equipment during its initial operation were as follows:

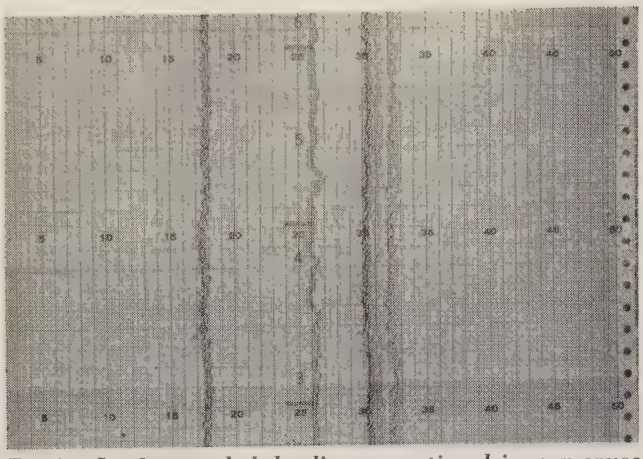

Fig. 9. Inadequate belt loading on section drive can cause oscillation as shown

1. It was very common to see a lack of proportional draw conditions progressing from the wet to dry end of the paper machine. Frequently a first or second drier section would be stretching the sheet excessively while an intermediate section operated with little or no draw at all (Fig. 7) followed again by a rather large differential in the next section.

2. It was very common to pull several sections of dryers with the calender stack. This is shown by a marked decrease in section differential when losing the sheet during a paper break (Fig. 8).

3. Long troublesome start ups which were frequent during the past years were now easily understood as they were often attempted with grossly improper section differentials.

4. On various occasions it would be noted a section speed would drift entirely out of range over a period of several hours.

5. Improper belt loading on sectional drives has been detected in the form of the section speed oscillating (Fig. 9).

Within a very short time machine tenders also noted these undesirable conditions which were only suspected to exist before the use of this equipment and would make appropriate adjustments to rectify the situation. An optimum set of draw condition is shown in Fig. 10.

On the basis of chart records over many months it was found the differential between the last two drier sections was normally small (usually 1 f.p.m. or less).

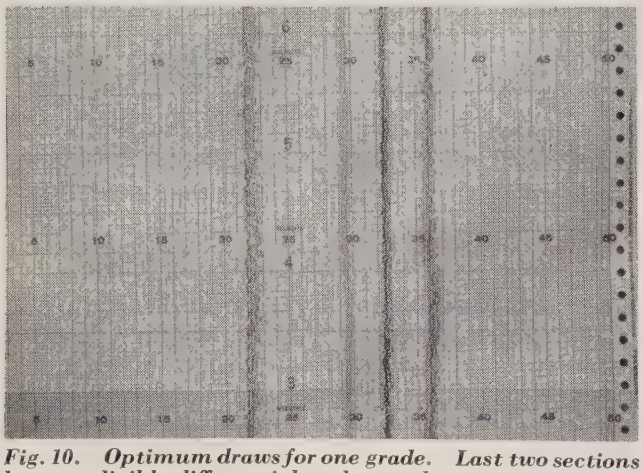

Fig. 10. Optimum draws for one grade. Last two sections have negligible differential and records are superimposed

Based on this knowledge the sections were tied together mechanically forming one long section. This has worked out very well. The magnetic pickup and slave EPUT meter have been reinstalled on a wet end press section.

Accuracy

It will be recalled that in the design section an accuracy analysis was made where the maximum theoretical error was computed. Practically, there are some other errors that creep into such a system that will cause inaccuracy as well as a certain amount of hunting or oversensitivity in the chart record. These are:

1. Nonuniform backlash in gear trains driving the driers.

2. Lack of exact mechanical relationships of the component parts of the paper machine. To obtain a rigorous accuracy of 0.1 f.p.m. at 1000 f.p.m., the drier diameter would have to be in the order of 60 in. This is a condition which undoubtedly does not exist.

3. During the life of a wire, there will be a certain amount of reduction in thickness which will influence the absolute accuracy of the system. The same may be said about carrier felts in the wet end press sections.

4. The use of too small a number of pulses in the counting period will detect many mechanical imperfections in the paper machine. The forementioned 10,000 pulse count period, which takes approximately 1.2 sec. at 1000 f.p.m., represents such a condition. When operating on this highly sensitive base, hunting over a band of about 2 f.p.m. occurs. Because of this, the 100,000 pulse base is used exclusively.

Add the above practical considerations together and the result is a random hunting motion over approximately a 1 f.p.m. band. Actually this is no handicap, as during visual examination of the chart, one sees the average of the print out and can easily tell when the record is changing $+^1/_4$ f.p.m. All chart records submitted for examination (Figs. 7–10) are 0 to 5% of couch speed equal to full scale.

CONCLUSIONS

While there are many conclusions that can be drawn from this project, perhaps the more significant ones can be summarized as follows:

1. From a practical standpoint the system has met our accuracy requirements.

2. During its $1^1/_2$ years of operation it has been well accepted by operating personnel as a tool to help them do a better job. This is somewhat substantiated by a recent request to have slave EPUT meters installed on the calender stack and reel.

3. Reliability is good and frequency of repair has been reasonable.

4. It is believed the system has more than met the conditions which were used to justify its installation. In a mill, where continual growth and expansion are occurring, it is difficult to look back and say that a particular project such as this has contributed greatly to production capacity. However, management feels that this is an operating tool which has helped substantially in our continual growth pattern.

A C. J. West Memorial Award paper. Presented at the meeting of the Lake States Section of TAPPI held in Menasha, Wis., May 12, 1959.

A Method to Determine the Degree of Wet Rub Resistance

F. R. ADAMS

Wet-rub resistance is a paper characteristic which has been of interest to the industry for many years; but which has been limited in its significance by the highly subjective methods used in its determination. This paper covers the conception and development of a wet-rub test which is entirely objective in nature, highly reproducible, and not limited by the paper coating base. By determining the degree of wet-rub resistance it is possible not only to separate the "blacks" from the "whites," but also to arrange the "grays" in sequential order. The simplicity of this test lends itself to routine control functions as well as the developmental uses indicated by its precision.

In past years, papers offered to the printing trade had either a high degree of wet-rub resistance or no resistance—a black or white proposition. With the growth of offset development, the printer and the papermaker have discovered that a sheet possessing only a limited amount of wet-rub resistance is desirable in many applications. To meet the demand for these special-property papers, much work has been done developing waterproofing latices and resins, and studying the problem of making wet-rub resistant starches.

With this interest in wet-rub properties, it has become increasingly desirable to know the precise ability of a coated sheet to resist destruction under combined conditions of moisture and abrasion and thus to be able to differentiate between wet rub and wet pick. In the past, this property has been measured more or less subjectively by placing a spot of water on the sheet in question, puddling it with the finger and arriving at a personalized decision. Another variation calls for a spot of water being placed on the sheet and the finger placed in the water and drawn across the sheet onto a black paper placed underneath and to the side; this rub being repeated a specified number of times. The black papers are then dried and the relative brightness of the spot of coating removed is taken as the measure of wet-rub resistance. The obvious sources of variation and error in this type of evaluation have led to the production of the various mechanical-arm types of wet-rub testers. These have taken numerous forms, subjected the sample to various actions, and rubbed it with everything from felt to corundum. Most of this equipment still has a built-in subjective factor in that the tester must decide the moment of the end point, or make comparisons with standards. Recently, a colorimetric method has been devised, based on the starch-iodine reaction which by the very nature of its indicator is rather limited in application.

Specifically, this paper relates to the conception and development of the equipment and procedures for obtaining measures of wet-rub resistance which are objective in nature and do not depend on total destruction of the coating layer for an end-point. In addition, this test gives reproducible measurements of the degree of wet-rub resistance, making it possible not only to separate the "blacks" from the "whites," but also to arrange the "grays" in sequential order. This equipment was fabricated originally for an investigation of surface tension reduction of press dampening fluids which was an extension of the work published by Bitter (*Tappi* 41, No. 8: 433 (1958)).

The central piece of equipment for this testing method (Fig. 1) consists basically of a rubber-covered roll running partially submerged in a pan of sample water. On this rides a movable steel roll upon which the sample to be tested is mounted with double-sided cellulose tape (Scotch no. 665). At this time any excess is trimmed off so that an essentially unbroken band of sample extends around the face of the roll (test area is 7.0686 sq. in.). After subjecting the mounted strip to a specified amount of wet abrasion, the water in the sample pan is filtered through a previously tared Whatman no. 42 filter paper, evaporated to dryness and reweighed to the nearest 0.1 mg. The gain in weight due to coating removed is then apparent and is taken as a measure of wet-rub resistance. The filter paper weight-gain may vary from zero for a totally wet-rub resistant sheet to a figure equaling the total coating weight for the sample in the case of some coated papers for letterpress printing applications.

In the early work with this apparatus, the sample water containing the abraded coating was decanted into a previously tared dish and evaporated to dryness before reweighing to determine the amount of coating removed. While theoretically this method is the most accurate, practically, it is also the most time consuming. When the change to the filter paper method was proposed, it was thought that the accuracy would suffer due to losses of dissolved materials and fines through the pores. Actually, closely controlled comparisons showed no significant differences in the results obtained.

In order to determine the degree of precision of the results obtained in the early phases of the test development, eight papers were selected for complete analysis.

1. 45-lb. Letterpress
2. 60-lb. Letterpress
3. 60-lb. Double-coated letterpress
4. 70-lb. Double-coated offset
5. 55-lb. Semioffset A
6. 55-lb. Semioffset B
7. 55-lb. Label
8. 55-lb. Offset label

The samples were intentionally chosen to be of well-aged production, so that adhesive aging effects would not alter the results significantly. Four sheets were taken at random from the sample and one $^3/_4$-in. strip cut from each sheet. These strips were then mounted on the steel wheel and given a 10-sec. wet-rub at 208 r.p.m. The 30-cc., distilled, sample water was then decanted into the filter paper and a 20-cc. pan rinse added. After filtering, the papers were quick-dried

F. Ray Adams, Chemical Engineer, International Paper Co., Research Division, South Glens Falls, N. Y.

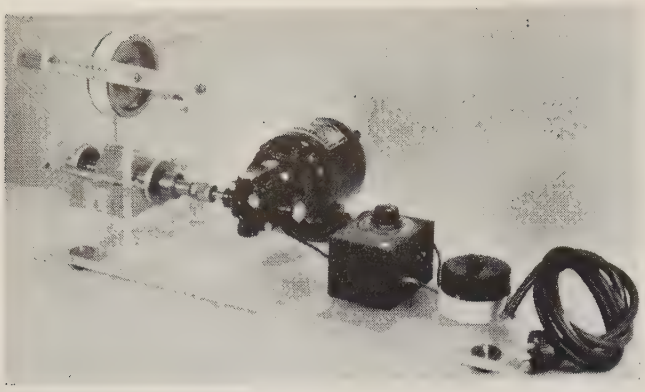

Fig. 1

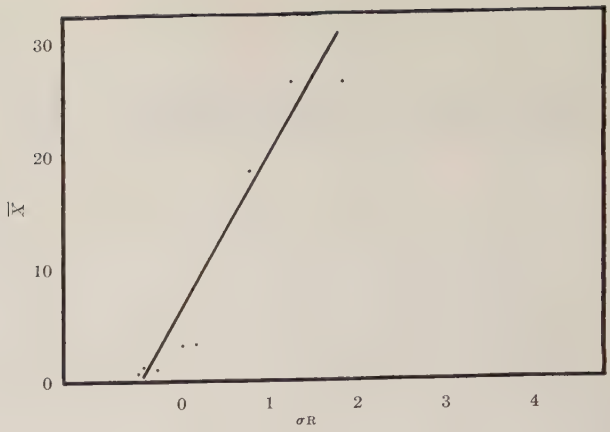

Fig. 2

under an infrared heat lamp and placed in the weighing oven for conditioning before weighing. It was found necessary to take this precaution since the weight differential on some samples was quite small. The results obtained were then plotted in a log book, and daily average and range of readings noted as well as the temperature, relative humidity, and water pH.

This procedure was repeated for nine days, so that 36 tests were performed on each sample. The data thus collected were analyzed and plotted in a number of different combinations to check the overall precision and to determine if correlations existed.

Table I contains data from the series with samples lumped together by general classification, while Table II is based on the same raw data but is split out as individual samples. These tables show a trend which can be simply stated: the greater the weight of coating removed, the greater the variation in the individual readings. Figure 2 is a plot of the data from Table II, and shows the type of relationship derived.

Going back to the raw data and assembling a cumulative frequency table for the daily range above and below X of all samples tested, the resultant curve (Fig. 3) was almost a textbook example of the superimposition of two curves. The range data were then split into letterpress and offset grades (Fig. 4). The dissimilarity between the shape of the curve for letterpress and offset sheets led to the plot of the range for each individual sample (Fig. 5). The family of curves derived indicated quite graphically the basic differences of the test samples and show a strong family relationship among the sheets of similar base.

Since all testing had been done in uncontrolled temperature and humidity conditions, the amount of coating removed was plotted as a function of relative humidity, as shown in Fig. 6. As might be expected the only group of papers to show sensitivity to high humidity were the letterpress papers (A), the semioffset (B) and true offset (C) papers remaining unaffected.

Sample range was also plotted against relative humidity (Fig. 7). Again as would be expected the letterpress sheets (A) show an increased range as humidity goes up. The true offset papers (C) remain unaffected, whereas the semioffset papers (B) show a slight rise. It is significant, however, that although the readings became more varied, the average remains the same.

The coating removed may appear in several forms in the sample water. First, and most common, is a milky suspension resulting from the separation of more or

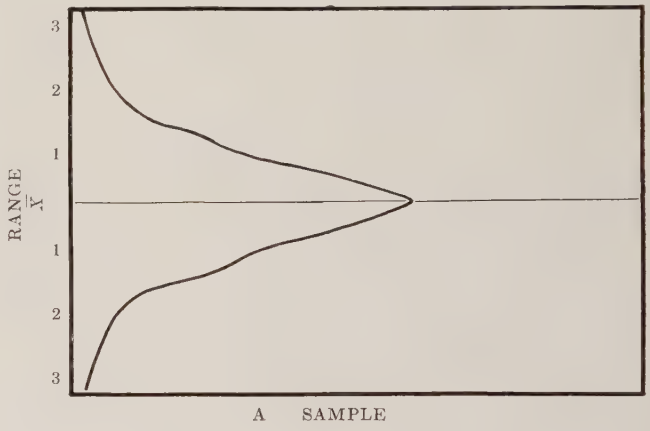

Fig. 3

less individual pigment particles, and their associated adhesive, from the coating layer. Some coatings separate in larger particles and are classified for convenience as flakes or plates. Flaking refers to the separation of coating in easily visible bits which are suspended in clear sample water. Plating is relatively rare and is characterized by wholesale separation of the coating layer as gross masses. Although these three classes are defined as separate conditions, there are coatings which give every possible combination, especially in the area between milking and flaking. It is because of these various types of coating removal that visual comparison

Table I

Classification	σ_R	*Within, %* 1 σ	2 σ	3 σ	$\bar{\bar{X}}$
All samples	0.0020	83.8	95.0	98.8	0.0101
Letterpress	0.0024	59.3	96.4	100	0.0237
All offset	0.0010	82.3	100	100	0.0019
Semioffset	0.0011	83.5	100	100	0.0033
True offset	0.0008	44.5	96.3	100	0.0010

Table II

Sample no.	*Class*	$\bar{\bar{X}}$	σ_R
1	Letterpress	0.0187	0.0017
2	Letterpress	0.0262	0.0020
3	Letterpress	0.0262	0.0025
4	True offset	0.0012	0.0007
5	Semioffset	0.0032	0.0011
6	Semioffset	0.0033	0.0012
7	Label	0.0010	0.0008
8	Offset label	0.0007	0.0007

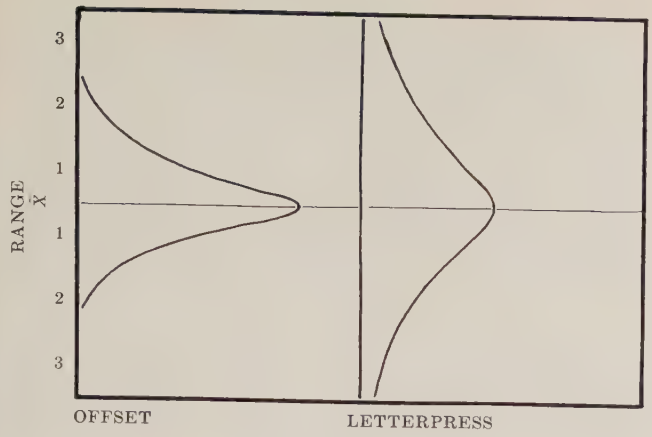

Fig. 4

with known suspensions is not practical as a method of rapid evaluation.

At this time a second series of tests was run using a number of basis weights of the same grades of paper. The data from this series was plotted in two ways. The plot of test range as a function of basis weight shows no particular correlation one way or another. When the data are plotted so that coating removed becomes a function of basis weight (Fig. 8) rather significantly the

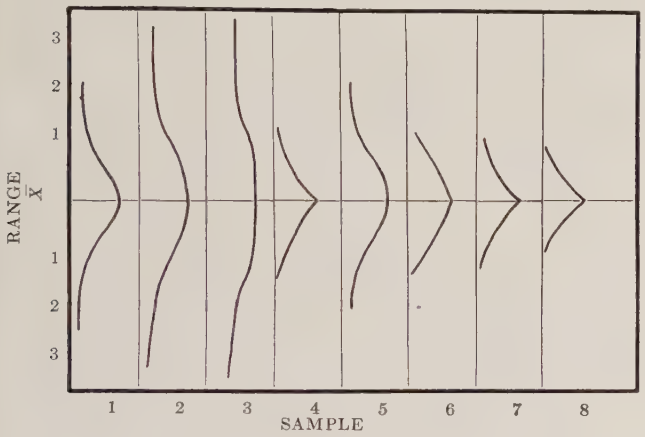

Fig. 5

data divide themselves into distinct categories. The letterpress papers (A) show an increase, the offset papers (C) remain basically constant throughout the weight range tested, and the semioffsets (B) fall in between.

To add to the understanding of the principles involved in this test, a number of letterpress and offset

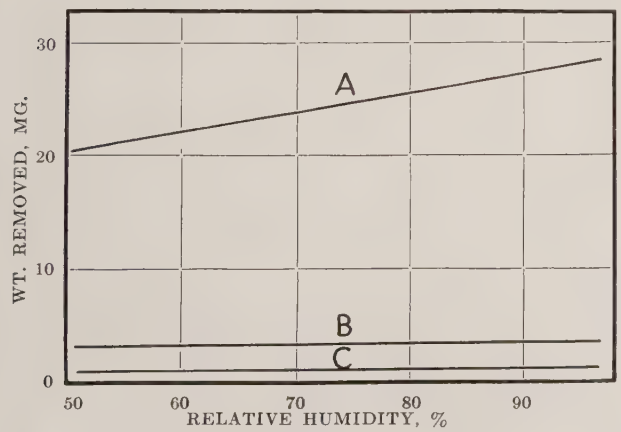

Fig. 6

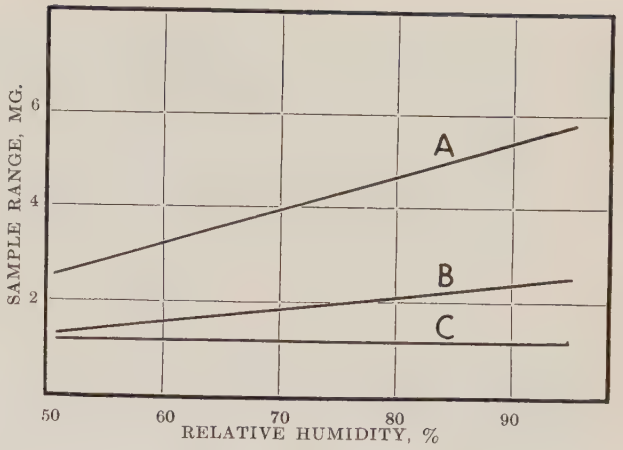

Fig. 7

sheets were tested under identical conditions except for the variation of wet-rub time. When weight removed was plotted as a function of time for the letterpress sheets (Fig. 9-A) a curvilinear relationship evolved, whereas the semioffset papers (Fig. 9-B) again produced a straight-line function. The true offset sheets (Fig. 9-C) also show a straight-line relationship between weight removed and time, but they differ from the

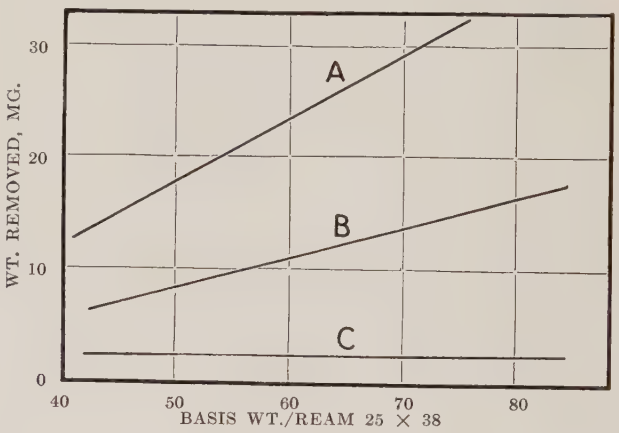

Fig. 8

semioffsets in that they have an initial period of total resistance which shifts the origin of the curve to the right. Certain sheets will produce a line with a break point resulting from a shift in the type of coating removal: from milking to flaking.

As the machine was originally designed, the coating removed was great enough in all samples that 10-sec.

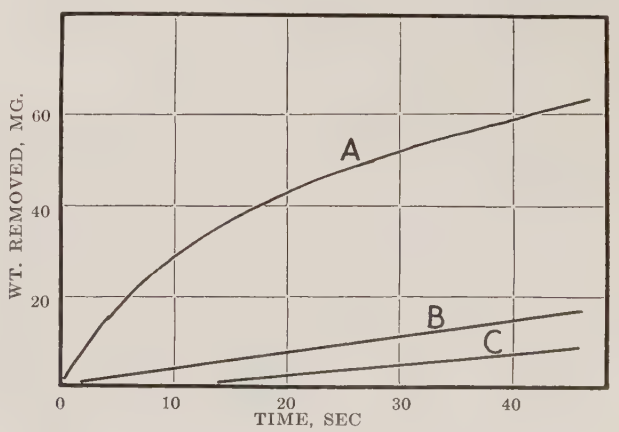

Fig. 9

wet-rub was taken as the standard time. Also, the weight of the upper steel roll was great enough to provide an adequate nip load. The effect of increasing the nip pressure was studied briefly to become familiar with the type of variation to be encountered. Figure 10 illustrates the load-weight gain relationship for one particular grade of letterpress paper, and is typical.

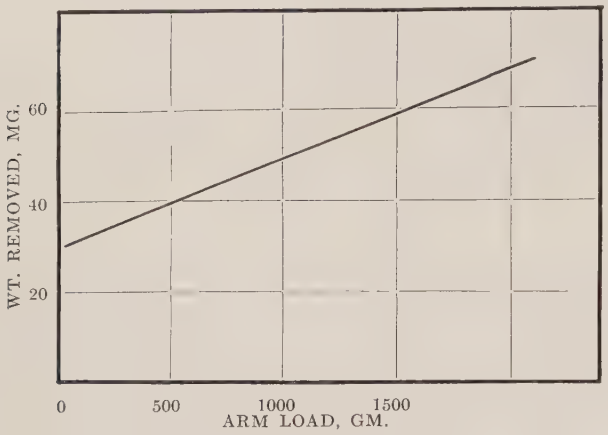

Fig. 10

One major source of error in the reciprocating-arm type of testers is the change in test results due to the change of the surface of the rubbing element. This necessitates frequent resurfacing or standardization of the test apparatus. To check what effect prolonged usage of the rubber roll had on test results, duplicate rolls were produced. One was used on all preliminary investigations and the number of actual tests noted. When over 2000 tests had been run on the original rubber roll, a special set of strips was run on this roll and a duplicate set run on its virgin twin. Results showed no significant difference between the action of the two rolls, which indicates that the constant flushing of the sample water stops any tendency of the roll to fill up and glaze over.

Numerous tests were performed on offset production of one mill, testing on the day the paper was made and continuing until the results stabilized (Fig. 11). In this way the curing cycle of the adhesive was observed as well as the final wet-rub value for that particular offset grade.

SUMMARY

Confining the conclusions to offset papers as a class, since this is the logical field of interest:

1. The lower the wet-rub value, the lower the variability.
2. Each adhesive base tends to give a particular frequency, distribution curve.
3. Wet-rub value is not affected by relative humidity.
4. Semioffset papers show no increase in range with increase in humidity.
5. True offset papers show no increase in range with humidity.
6. wet-rub value of true offset paper is not affected by basis weight.
7. Wet-rub value increased with time of wet rub.
8. Wet-rub value increases directly with nip load.
9. Curing cycle can be determined by repeated tests.

With the above test series results at hand, and the test conditions as specified, the papers tested to date fall into two distinct categories. The first comprises the offset and semioffset papers; the second, the letterpress grades. The offset papers will show a filter paper gain from 0 to 15 mg. with the majority showing 10 or less. The full offsets will usually fall in the 0- to 2-mg. range, and the semioffset cover the remainder. The letterpress sheets run from 16 mg. up to a figure equaling the total coating weight on some strips.

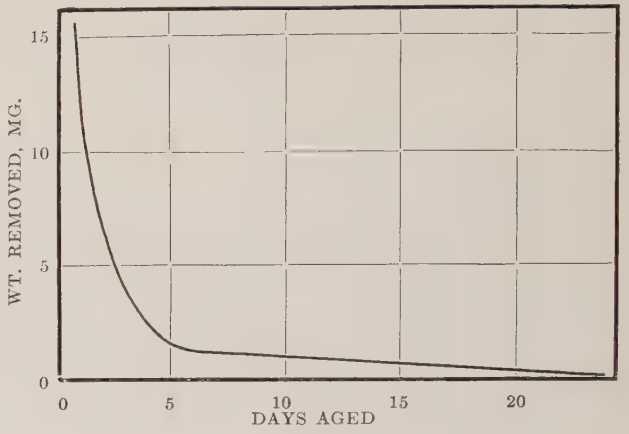

Fig. 11

In cutting the strips for testing, it has been found to be immaterial whether they are cut in the machine or cross direction. Sets of strips cut in each direction will give essentially identical mean values. However, strips

Table III

Competitive sheets	$\bar{\bar{X}}_9$	$\bar{R}t$
1. Semioffset A	8.6	2.2
2. Letterpress A	15.6	4.4
3. Letterpress B	22.6	6.3
4. Letterpress C	13.5	5.2
5. Offset C	1.6	1.9
6. Semioffset D	3.0	2.3
7. Offset D	2.8	2.3
8. Offset E	1.4	1.5

cut in the cross direction will usually have a smaller range than those cut in the machine direction, e.g., strips from a sample of 55-lb semi-offset gave the following:

$\bar{\bar{X}}_{\text{Machine}}$... 0.0103 g. R_{Machine} ... ±0.0027 g.
$\bar{\bar{X}}_{\text{Cross}}$... 0.0101 g. R_{Cross} ... ±0.0012 g.

For this reason, the preferred strip orientation is in the cross-direction.

A group of competitive sheets was tested to give the test a broader base and the data assembled in Table III. It will be noted that the wet-rub value for these samples fall in the proper category, but the range is generally higher than for the in-mill samples. This is undoubtedly due to the amount of handling these sheets received prior to testing.

From the data thus collected, it is concluded that this test method gives information with a reasonable precision and accuracy unobtainable by any other method known at the present time. As such, this test should fill a basic need for several segments of the industry:

1. The manufacturer of offset papers: To know that his product is consistently uniform.
2. The printer: To help differentiate between paper and press problems.
3. The research organization: As an aid in formulating coatings for optimum balances.
4. The supplier: As a test to aid in their continuing development of new products for the paper industry.

With the above facts and data at our disposal, we feel that this testing procedure can be of value in a wide and varied field of application.

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Deresination of Sulfite Pulps with Nonionic Surfactants

D. O'MEARA and R. M. L. PATERSON

The deresination of calcium-base sulfite pulps from a mixture of northern British Columbia coniferous woods has been studied. By adding surfactants during caustic extraction, the resin level can be controlled down to 0.05%. Ether-linked nonionics have been found to be the most effective class of compound. Homologous series of polyoxyethylated adducts of tridecanol, nonyl-, dodecyl-, and dinonyl phenols have been examined over a wide range of ethylene oxide content. It was found that deresination efficiency is influenced by both the reaction conditions and the structure of the surfactant. Each hydrophobic base gave a characteristic deresination efficiency related to molecular size. The efficiency was greatest at a common ethylene oxide content of 68–76% by weight, depending on extraction temperature. The ultimate resin level further depends on caustic addition, reaction temperature, and amount of surfactant used. Cottonwood behaves differently in deresination. Wood seasoning and caustic strength have a pronounced effect on the final resin content. Surfactant addition was much less effective than with coniferous pulps, and a lower ethylene oxide content (65%) gave best results. Deresination is a rapid process at all temperatures, thus saponification is not a significant factor. Resin soaps formed by caustic disperse the resin which is then emulsified and suspended by surfactant.

THREE species of northern British Columbia coniferous woods contain from 1.5 to 2.0% of resin measured as alcohol-benzene solubles. (Spruce—*Picea sitchensis*, 1.98%; hemlock—*Tsuga heterophylla*, 1.66%; balsam—*Abies amabilis*, 1.41% on moisture-free wood, are typical values). Cottonwood—*Populus trichocarpa* var. *hastata*—a hardwood, contains 2.17% extractives when fresh. All four species, in varying proportions, are used in our Prince Rupert mill for the preparation of dissolving grade, high alpha-cellulose pulps.

In the preparation of paper pulp it may be satisfactory if the resin is merely dispersed among the fibers. However, in the case of dissolving pulps it is essential that the resin content be reduced to controlled low levels. This is necessary because of the deleterious effect of uncontrolled amounts of resin on acetate and viscose properties.

Rapson (*1*) and Mutton (*2*) have reviewed the various methods that have been proposed for the removal of resin. Of these the most effective are the following:

Seasoning of wood or chips before cooking; this is especially effective with hardwoods.
Removal of elemental fines from raw stock.
The use of oxidizing agents, e.g., chlorine dioxide in place of chlorine for delignification.
The use of a caustic extraction stage.
The addition of a surfactant/emulsifier to the caustic extraction stage.

Figure 1 shows the normal pattern of resin removal during sulfite cooking and subsequent purification of a coniferous and a hardwood pulp. It can be seen that with the coniferous wood some 80% of the resin is removed in cooking so that the raw pulp has a resin content of about 0.6 to 0.7%. About 90% of this residual resin can be removed in subsequent processing. Virtually all this deresination is accomplished in the caustic extraction stage. Chlorination and bleaching make relatively little contribution. It is clear from Fig. 1 that very low resin levels can only be attained by the addition of surfactant. The deresination of the hardwood and cottonwood follow the same general pattern. It is the controlled removal of resin in the caustic extraction stage that forms the subject of this paper.

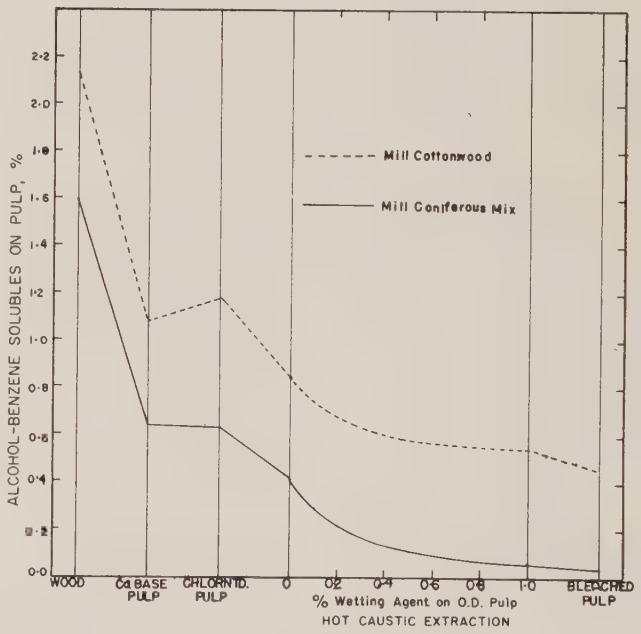

Fig. 1. Resin levels through pulp purification stages

The application of surface active agents in cooking,

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chlorination, and bleaching of sulfite pulps does confer certain benefits. Thus in all these stages surfactants aid mixing, improve penetration, and generally promote more uniform reaction. However, there is little effect on resin removal owing to the unfavorable environment and the relatively low temperatures normally employed. The same general considerations apply to the use of surfactants in cold caustic extraction where the high caustic concentration results in "salting out" of most wetting agents.

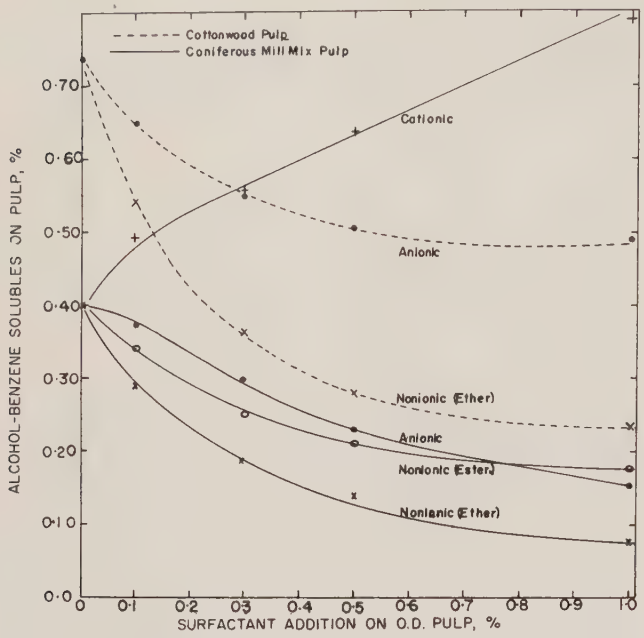


Fig. 2. Effect of surfactant type on deresination during 6% caustic extraction at 140°C.

Maximum deresination efficiency occurs when surfactants are applied in a hot caustic-extraction stage. Early additives to a caustic extraction stage for the purpose of lowering pulp resin content included sulfonated castor oil, turkey red oil, fatty-acid soaps, complex phosphates, and combinations of soap and phosphates. The use of surface active agents was disclosed in a patent issued to Rapson and Wayman (*3*) and subsequently formed the subject of a paper by Rapson (*1*). Rapson reviewed briefly a number of additives and detergent builders and concluded that the most effective deresinating agents were nonionic surfactants. We have examined other classes of surfactant, but found them to be uniformly inferior under hot caustic conditions either because of reduced activity or because of chemical instability, e.g., ester-linked nonionics. Typical examples of the principal classes are shown in Fig. 2. While most compounds will cause some reduction in pulp resin only the ether-linked nonionics are capable of giving the low levels necessary for a dissolving-grade pulp at an economic rate of addition.

The object of the present work was to determine the structural factors and reaction conditions controlling the efficiency of ether-linked nonionic surfactants in deresination of coniferous and hardwood sulfite pulps.

EXPERIMENTAL

Mill chlorinated calcium-base sulfite pulps were used in these studies. The coniferous pulp was prepared from a mixture of three species of northern British Columbia woods (*Tsuga heterophylla* 60%, *Picea sitchensis* 20%, and *Abies amabilis* 15%, containing 1.5 to 2.0% alcohol-benzene solubles.) A hardwood pulp from cottonwood (*Populus trichocarpa* var. *hastata* containing 2.2% resin) was also used. Typical properties of chlorinated pulps were: viscosity (1% cupriethylenediamine), 200 to 300 cp.; K. no. (25 ml.), 1 to 1.5: alcohol-benzene solubles, 0.6 to 0.7%. Caustic extractions were carried out on a pilot-plant scale using 50 to 100 g. ovendry (O.D.) batches directly heated in an autoclave. The conditions, except as indicated in the text, were: 10% O.D. consistency, 20 min. at 140°C., 6% caustic on pulp.

DERESINATION OF PULPS

Hydrophobic–Hydrophilic Balance

Nonionic surfactants are unusual because the hydrophobic-hydrophilic balance can be adjusted to give compounds of widely different solubility and performance characteristics. This can be done by changing the length of the polyoxyethylene chain.

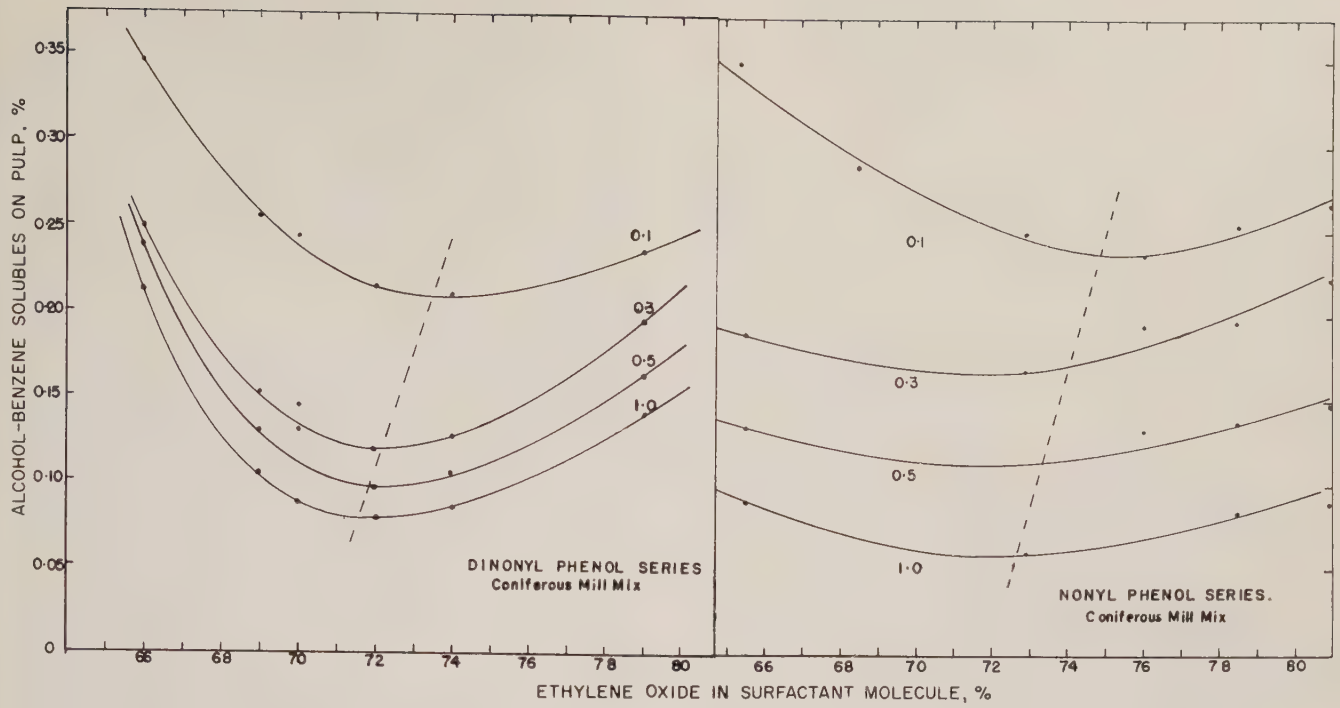
It is known that deresination efficiency varies between nonionic surfactant compounds in a homologous series, depending on the amount of ethylene oxide condensed with the base. This is further demonstrated in Figs. 3 and 4 where deresination performance with dinonyl- and nonyl phenol-based series are shown. At any surfactant addition level, residual pulp resin may be reduced by as much as half by selecting the proper composition within the series. Similar data on two other series of compounds are given in Table I.

Rapson (*1*) has reported that optimum deresination occurs when the hydrophobic-hydrophilic balance is adjusted to the particular base used. He found this optimum between 57.5 and 70% ethylene oxide content, depending on whether cashew-nut oil, tall oil, nonyl phenol, or rosin condensates were used.

We have studied polyoxyethylene condensates of four bases (tridecanol, nonyl phenol, dodecyl phenol, and dinonyl phenol) in the removal of resin from coniferous pulps. These compounds represented a range of ethylene oxide content from 61 to 85%. As is demonstrated in Table I and Figs. 3 and 4, optimum deresination occurred at the same approximate level of ethylene oxide content (72 to 76%) with all bases studied under the same treatment conditions.

Just as it is possible to vary surfactant properties by changing the length of the hydrophilic polyether chain, properties are also altered by using different hydrophobic bases. Thus, maximum performance in resin removal varies according to base used, as shown in Table I where surfactants derived from four bases have been investigated over a range of ethylene oxide content and addition. The results in Table I were obtained using different raw pulps of varying resin content with the different bases. These data are equated to a common efficiency scale through comparison with a control compound run in each series of trials. The control compound was arbitrarily assigned a value of 100. Other results obtained on a common chlorinated pulp are given in Table II.

The choice of optimum hydrophobic base appears to relate to addition level. In general dodecyl- and dinonyl phenol bases were better than nonyl phenol



Figs. 3 and 4. Effect of ethylene oxide content on deresination during 6% caustic extraction at 140°C.
The numbers on the curves indicate the percentage addition of surfactant.

and these three were superior to tridecanol. It is interesting that sensitivity to changes in ethylene oxide content are just the reverse of this order. This probably reflects molecular weight and solubility characteristics.

Typical results of experiments with compounds derived from other hydrophobic bases are shown in Table III. Ethylene oxide contents were between 70 and 80%. Again relative efficiency figures were obtained through comparison with a control compound. Deresination efficiency increases with hydrocarbon chain length and also with the molecular weight. This is shown by both the alkyl phenol series—octyl to dodecyl— and again for the decanol—hexadecanol series. It is evident that octadecanol (C_{18}) is inferior to dodecanol (C_{12}). However oleyl alcohol (C_{18}), which contains a double bond, is highly efficient—the double bond presumably reducing the effective chain length to that of about C_{14-16}. The straight-chain dodecanol (C_{12}) is superior to the branched-chain tridecanol (C_{13}). Thus, with compounds based on aliphatic alcohols, efficiency is influenced both by chain

Table I. Effect of Ethylene Oxide Content with Different Nonionic Bases at 140°C.
Per Cent Alcohol-Benzene Solubles

Base / *Addition level, %* → / *Ethylene oxide, %*	*Tridecanol*				*Nonyl phenol*				*Dodecyl phenol*				*Dinonyl phenol*			
	0.1	*0.3*	*0.5*	*1.0*	*0.1*	*0.3*	*0.5*	*1.0*	*0.1*	*0.3*	*0.5*	*1.0*	*0.1*	*0.3*	*0.5*	*1.0*
61	0.38	0.32	0.23	0.17	...	...	...	...	...	...	...	...	...	...	...	...
63	...	...	...	...	...	...	...	...	0.30	0.20	0.14	0.09	...	...	...	...
64	...	...	...	...	0.36	0.20	0.14	0.11	...	...	...	...	...	...	...	...
66	...	...	...	...	0.30	0.19	0.14	0.09	0.27	0.17	0.13	0.08	0.35	0.25	0.24	0.21
67	...	...	0.18	0.10	...	...	...	...	...	...	...	...	...	...	...	...
69	...	...	...	...	0.29	0.18	0.11	0.07	...	...	...	...	0.26	0.15	0.13	0.10
70	...	...	...	...	...	...	...	...	...	...	...	...	0.24	0.14	0.13	0.09
72	...	...	...	...	...	...	...	...	...	...	...	...	0.22	0.12	0.10	0.08
73	0.27	0.20	0.14	0.07	0.25	0.17	0.12	0.06	...	...	...	...	...	...	...	...
74	...	...	...	...	...	...	...	...	...	...	...	...	0.21	0.13	0.11	0.09
75	...	...	...	...	...	...	...	...	0.20	0.11	0.07	0.05	...	...	...	...
76	...	...	...	...	0.24	0.20	0.13	0.08	...	...	...	...	...	...	...	...
77	0.25	0.18	0.12	0.06	...	...	...	...	0.23	0.12	0.07	0.05	...	...	...	...
78	...	...	...	...	0.26	0.20	0.14	0.08	...	...	...	...	...	...	...	...
79	...	...	...	...	...	...	...	...	...	...	...	...	0.24	0.20	0.16	0.14
80	0.27	0.19	0.13	0.08	0.27	0.22	0.15	0.09	...	...	...	...	...	...	...	...
82	0.29	0.21	0.14	0.09	...	...	...	...	...	...	...	...	...	...	...	...
85	0.30	0.26	0.16	0.14	...	...	...	...	...	...	...	...	...	...	...	...
Nonyl Phenol Control																
66	0.26	0.17	0.12	0.07	0.30	0.19	0.14	0.09	0.25	0.13	0.10	0.07	0.31	0.16	0.12	0.08
Relative Efficiency, %																
65	80	65	60	60	90	100	100	90	90	70	75	85	80	55	40	...
70	90	75	80	85	110	110	125	135	110	90	100	105	125	115	100	90
75	100	90	95	110	125	110	110	135	125	120	135	130	150	120	105	85
80	100	90	95	95	110	85	95	100	90	95	...	...	125	75	70	55
85	80	65	75	50	...	...	...	...	...	...	...	...	...	...	...	...

Table II. Comparison of Hydrophobic Bases with Optimum Ethylene Oxide Content

Base compd. addn. level, % → / Base compd.	E.O.,[b] %	0	0.1	0.3	0.5	1.0
		A-Ba Solubles at 140°C.				
Nonyl phenol (control)	65	0.36	0.27	0.17	0.12	0.07
Tridecanol	77	...	0.25	0.18	0.12	0.08
Dodecyl phenol	75	...	0.22	0.14	0.09	0.06
Dinonyl phenol	72	...	0.21	0.11	0.08	0.07
Nonyl phenol (control)	65	0.39	0.29	0.18	0.15	0.08
Tridecanol	77	...	0.26	0.19	0.14	0.07
Nonyl phenol	73	...	0.25	0.16	0.11	0.06
		Relative Efficiency, %				
Tridecanol	77	...	110	95	100	90
Dodecyl phenol	75	...	125	120	135	120
Dinonyl phenol	72	...	130	155	150	100
Tridecanol	77	...	110	95	105	105
Nonyl phenol	73	...	115	115	135	135

[a] Alcohol-benzene.
[b] Ethylene oxide.

length and the presence of branching or interfering groups in the alkyl chain. The other compounds in Table III were all relatively inefficient although their cloud points were of the same order as those of highly efficient surfactants. This is further indication of the importance of the hydrophobic base in pulp deresination.

Level of Addition

The absolute effect on deresination with varying surfactant addition is shown in Figs. 1 and 2, as well as Figs. 3 and 4. With the most successful compounds it is possible to lower residual resin content in pulp from 0.25 to 0.05% by increasing surfactant application from 0.1 to 1.0%. Over the addition range of 0.5 to 1.0% there is a rapidly diminishing action, and it is doubtful if further addition above 1% achieves any useful result.

Level of addition is also shown to affect optimum hydrophilic balance as shown in Figs. 3 and 4. For each level of addition there is an optimum ethylene oxide content. Thus with the nonyl- and dinonyl phenol-based series optimum ethylene oxide content shifted from 74 to 72% as the amount of surfactant added was increased from 0.1 to 1.0% on pulp. This effect was not as evident with dodecyl phenol- and tridecanol-based compounds.

Choice of the most efficient hydrophobic base is also influenced by surfactant addition level as shown in Tables I and II. Best performance at 140°C., over 0.5 to 1.0% addition, occurred with dodecyl- followed by nonyl phenol, while at 0.1 to 0.5% addition dinonyl phenol was superior. Nonyl phenol gave uniformly better results than tridecanol. The relative order of efficiency for these bases probably changes with temperature.

Reaction Conditions

Caustic is an important component in the deresination reaction even when using nonionic surfactants. This is shown in Fig. 5 where the use of surfactant without caustic gave no resin removal. Further, as the level of caustic addition is reduced below 6.0% on pulp, the final resin level depends increasingly on the amount of caustic as well as on the amount of surfactant applied.

Prolonged retention time is not critical to resin removal, as shown in Fig. 6 where time is varied at different temperatures with different nonionic surfactants. In these experiments the desired maximum temperature was reached as quickly as possible after mixing the pulp and reagents. The results show that final resin level depends on the temperature used, but at each temperature this level is reached within 5 to 10 min. with coniferous pulps. This is not an important consideration in the manufacture of dissolving pulps where caustic extraction of lesser carbohydrates occurs at a slower rate which sets reaction time beyond that required for successful deresination. Conversely, a rapid extraction of paper-pulp grades preserves carbohydrate yield and pulp strength properties.

Extraction temperature has a pronounced effect on deresination. This is illustrated in Figs. 7 and 8 and Table IV. Resin removal passes through a maximum as the temperature is raised from 60 to 160°C. This maximum changes with the level of surfactant addition and with per cent ethylene oxide in the surfactant molecule.

The top curve of Fig. 7 shows that with caustic alone the residual resin reaches a minimum between 90 and 100°C. This deresination phenomenon must result from the action of resin soaps formed by the attack of

Table III. Properties and Performance of Different Hydrophobic Bases

Base type	Base compound	Mol. wt.	Ethylene oxide, %	Cloud point, °C.	Performance index at 140°C.
Alkyl phenol	Nonyl phenol	220	65	56[a]	100[b]
	Dinonyl phenol	342	72.5	77.5	145–155
	Dodecyl phenol	262	76	80.5	140–145
	Nonyl phenol	220	73	80	135
	Octyl phenol	206	68	67[a]	100
Alkyl alcohol	Oleyl alcohol (C_{18})	268	77	90	150
	Octadecanol (Tallow) (C_{18})	270	77	85	115
	Dodecanol (C_{12}) (Lauryl alcohol)	186	78	88	130
Branched chain aliphatic alcohol	Hexadecanol (C_{16})	242	78	78.5	115–120
	Tridecanol (C_{13})	200	77	74	100
	Decanol (C_{10})	158	81	86.5	30–40
Resin alcohol	Abietyl alcohol	298	70	70–80[a]	70
Polyfunctional hydroxy acid	Ricinoleic acid	299	70	85[a]	25
Polypropylene oxide	$(C_3H_6O)_{25-30}$	1500–1800	40–50	57[a]	30

[a] Cloud points measured in water—other cloud points measured in 5% NaCl.
[b] Efficiency in per cent relative to nonyl phenol control with 65% ethylene oxide.

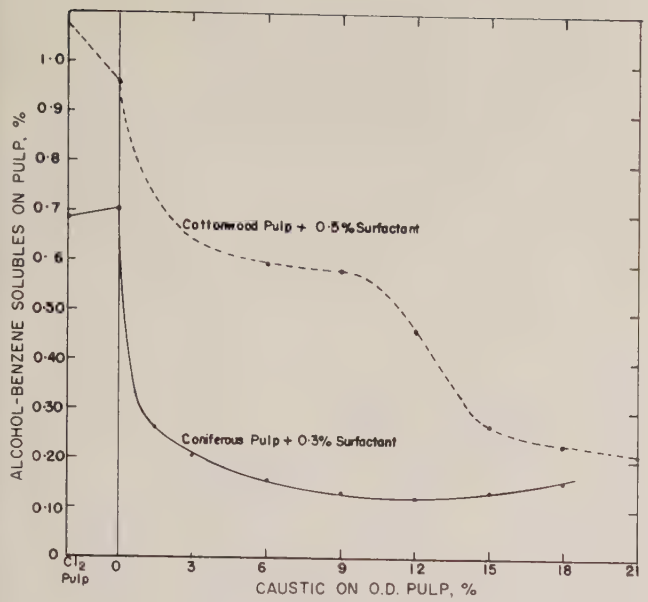


Fig. 5. Effect of caustic addition on deresination at 140°C.

caustic on acid resin constituents. When a nonionic surfactant is added, the resin level is reduced at all temperatures, and the temperature of lowest residual resin changes. The position of the minimum depends both on the amount of surfactant used and its ethylene oxide content. Furthermore, for any given level of surfactant addition the optimum ethylene oxide content depends on the temperature used.

This important interaction between optimum ethylene oxide content and temperature stems basically from the inverse solubility of the polyethylene oxide chain. As the temperature approaches and exceeds the cloud point the emulsifying and suspending power of the surfactant, and hence deresination, pass through a maximum. As the temperature is raised a higher ethylene oxide content is necessary to maintain solubility. Varying temperature from 60 to 160°C. requires as much as 8% adjustment in ethylene oxide content of

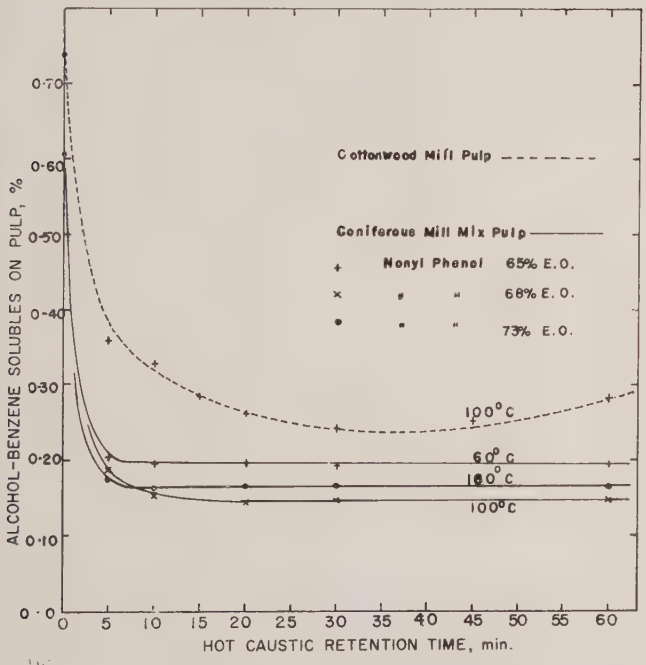


Fig. 6. Effect of time on deresination in 6% caustic extraction when applying 0.5% surfactant on cottonwood, and 0.3% on coniferous pulp

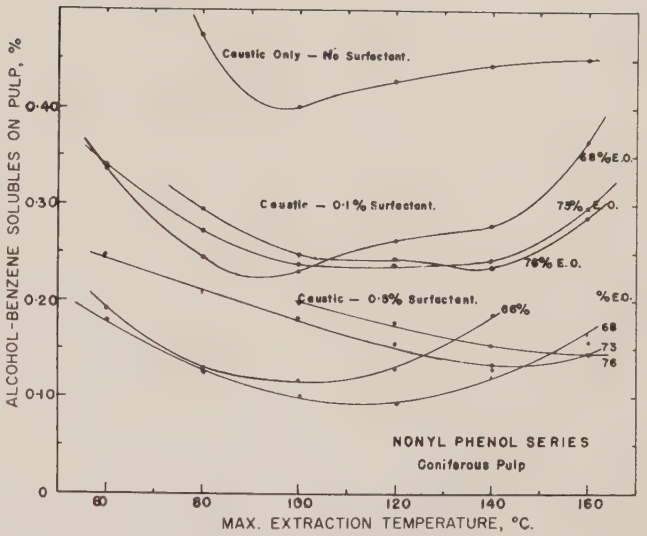


Fig. 7. Effect of temperature on deresination in 6% caustic extraction

the surfactant to achieve optimum results. It is evident that the lowest level of residual resin for the nonyl phenol series is obtained between 90 and 120°C., depending on level of application.

Wood Species

The discussion so far has centered on deresination of coniferous pulps which behave in a reasonably uniform way. Deresination of calcium-base sulfite pulp made from cottonwood (*Populus trichocarpa* var. *hastata*) was also examined and found to be variable depending on the amount of wood seasoning that had occurred. The seasoning effect is demonstrated in Fig. 9 where fresh and partially seasoned cottonwood are compared to a coniferous mix when treated with nonyl phenol-based surfactants. The "fresh" cottonwood pulp was cooked within 3 to 4 days of cutting. It is clear that with this pulp the final resin level was high and was independent of ethylene oxide content in the surfactant. Variation in results probably reflects experimen-

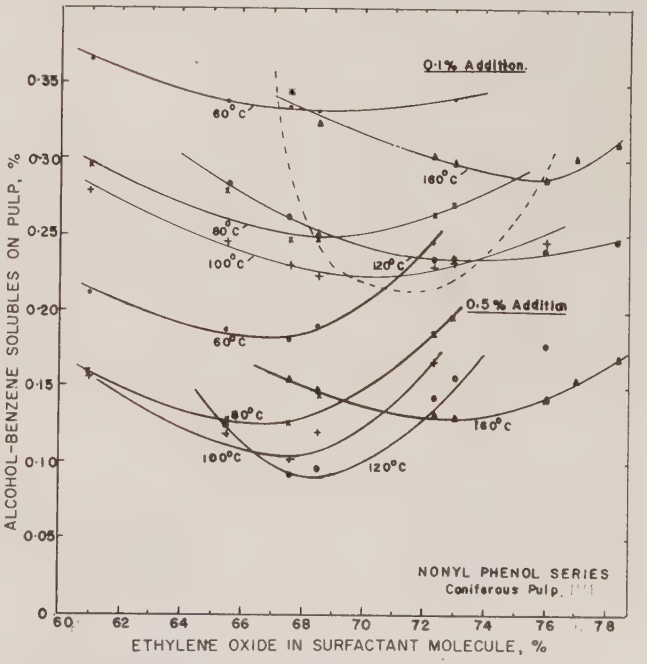


Fig. 8. Effect of ethylene oxide content on deresination in 6% caustic extraction at different temperatures

Table IV. Effect of Caustic Extraction Temperature on Deresination

Per Cent Alcohol-Benzene Solubles with 0.1 and 0.5% Polyoxyethylated Nonyl Phenol Addition

Ethylene oxide, %	Treatment temperature, °C. 60	80	100	120	140	160
	Alcohol-benzene solubles, %					
	0.1% Addition					
61	0.37	0.30	0.28	...	...	...
65.5	0.34	0.29	0.25	0.28	0.29	...
68	0.34	0.25	0.23	0.26	0.28	0.37
68.5	0.33	0.25	0.22	0.25	0.26	0.32
72	0.34	0.26	0.23	0.24	0.25	0.30
73	0.34	0.27	0.24	0.23	0.24	0.28
76	...	...	0.25	0.24	0.24	0.29
78.5	...	...	...	0.25	0.25	0.31
	0.5% Addition					
61	0.21	0.16	0.16	...	...	...
65.5	0.19	0.13	0.12	0.13	0.16	...
68	0.18	0.13	0.10	0.09	0.13	0.15
68.5	0.21	0.15	0.13	0.13	0.10	0.14
72	0.24	0.19	0.17	0.15	0.13	0.14
73	0.25	0.20	0.18	0.16	0.13	0.13
76	...	...	0.20	0.18	0.15	0.14
78.5	...	...	...	0.20	0.19	0.17

tal error rather than any differences in processing behavior. The "seasoned" cottonwood pulp behaved more like a normal coniferous pulp. However, the final resin level was higher than with coniferous pulp. The optimum ethylene oxide content in the nonyl phenol surfactant series has been established at 65% for these pulps. This is lower than with coniferous pulps. A further comparison of overall deresination for cottonwood that has been normally seasoned is shown in Fig. 1. A fully seasoned wood, however, gives pulp resin levels equivalent to those obtained with coniferous pulp.

Cottonwood pulp responded differently to caustic addition, as shown in Fig. 5. The plateau occurring between 3 and 9% caustic must result from some qualitative difference in hardwood resin. The change in behavior between 9 and 15% caustic is probably due to saponification of ester constituents which are much higher than in softwood pulps (*2*).

In relation to reaction time the cottonwood pulp behaved like the coniferous pulps, but resin removal was more time dependent, reflecting the higher initial resin content and the greater proportion of esters in hardwood resin. Further, the final resin content rose if treatment was prolonged. This is probably owing to the redeposition of emulsified resin; redeposition is a well-known factor in detergency and soil removal (*4*).

Although the final resin level of cottonwood pulps is affected by extraction temperature, caustic addition, percentage ethylene oxide, and surfactant base it cannot be reduced to a level comparable to that of normal softwood pulp except by special treatments, e.g., extensive wood seasoning, deflouring, or replacement of chlorine by chlorine dioxide in the chlorination stage (*1, 6*).

MECHANISM OF DERESINATION

Successful pulp deresination results from the proper control of a number of factors. The process is essentially similar to that of soil removal and detergency. It may be divided into three significant stages:

Wetting of the fiber and resin to aid penetration by the alkali and surfactant.

Subdivision of the resin aggregate, freeing resin particles from the fiber and dispersing these in solution, and

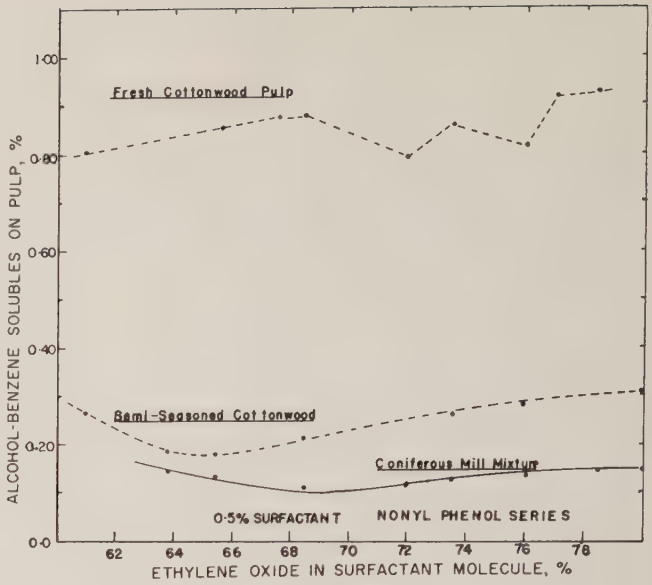


Fig. 9. Effect of ethylene oxide content on deresination of cottonwood in 6% caustic extraction at 140°C.

Dissolving or stabilizing the dispersed resin particles in such a way that they will not redeposit on the fiber.

The active agencies in these three phases are nonionic surfactant, heat, caustic and resin soaps formed by caustic attack on the resin.

Nonionic surfactants are excellent wetting agents and emulsifiers, good dispersants, and suspending or stabilizing agents. The surfactant aids each stage of the process by improving the wetting, and reducing the mechanical or thermal energy necessary to break the resin-to-resin, and resin-to-fiber bonds. Further, it promotes dispersion, emulsification, and stabilizes the resulting suspension. The resin soaps formed as above also assist in these processes.

Heat is important to deresination. Increased temperature weakens the absorptive bonds between resin and cellulose and lowers the resin viscosity, thus increasing its mobility through the fiber and reducing its resistance to shear during dispersion. The high temperature also provides part of the energy necessary to separate the resin from the fiber and disperse it, while accelerating its saponification. The minimum in the curve of residual resin versus temperature, Fig. 7, is the resultant of two opposing effects. As the temperature increases, the thermal energy and dispersive action increase, aiding resin removal, but the solubility, emulsifying and suspending power of the surfactant falls away beyond the cloud point temperature. As shown in Fig. 8 this minimum moves to higher temperatures as the per cent ethylene oxide increases.

The importance of caustic to resin removal is shown by the relatively poor performance of the surfactant alone (Fig. 5). The primary process in the first phase is attack on the resin by the caustic with the formation of resin soaps *in situ*. The free acid constituents are dissolved and the nascent soap formed is particularly effective in giving dispersion. This same action is utilized in a number of washing processes because of the superior detergency which results (*5*). Resin soaps account, in part, for the fact that pulp deresination is a rapid process, the rate of which is independent of temperature.

After the initial caustic attack on resin acids, the active processes are probably mechanical and thermal dispersion of esters and unsaponifiable components, plus emulsification of these by the nonionic surfactant. Saponification of the esters does not appear to be a significant factor in deresination, since under heterogeneous conditions this is a relatively slow process (*6*), the rate of which is temperature dependent (*7*). Figure 6 clearly indicates that resin removal is complete after a short time at temperature, and that the rate is independent of the temperature. However, once the resin is in suspension, saponification may proceed under very favorable conditions and this will aid in preventing redeposition. The importance of emulsification to the process is demonstrated by the fact that the most efficient class of surfactants for pulp resin removal is that with the greatest emulsifying power. Similar materials with good detergency and wetting ability such as the polypropylene oxide-polyethylene oxide types, are very much inferior (Table III).

This proposed mechanism highlights the role of resin soaps in deresination. Local soap formation promotes rapid and efficient dispersion. These soaps, as anionic surfactants, also aid in the dispersion and penetration process. This indicates why anionic surfactants as a class are not efficient deresinating agents since their effect is additive to that of about 0.3 to 0.5% of anionic soap already present, i.e., the response per unit addition is very much lower above this range. A third, less obvious contribution of the resin soaps is in raising the high temperature solubility and suspending power of the nonionic surfactant. The normal extraction temperature is well above the cloud point for the surfactant, particularly in the presence of caustic which depresses the solubility. Anionic surfactants raise the cloud point and improve the solubility of nonionics at high temperatures. Sodium oleate, which is a major constituent of resin soap, is also an excellent suspending agent thus helping to minimize redeposition.

The movement of optimum ethylene oxide content to lower values as the addition level increases (Figs. 3 and 4) is further evidence that the resin soaps are one of the active components in the deresination system. This shift is due to the proportionately greater effect of the resin soaps at low addition levels. Further, sodium oleate and the other components are low-titer soaps which give maximum detergency at low temperatures. Thus with low levels of surfactant addition a higher ethylene oxide content is necessary to get the proper balance for the extraction temperature. At higher levels the surfactant predominates and a lower per cent ethylene oxide is required. This is further shown in Fig. 7 where low levels of surfactant addition across a broad temperature range yield curves that have both a minimum and a point of inflection. This indicates that the final resin level results from the independent action of both the resin soaps and the added surfactant. When more surfactant is added, however, the effect of the resin soaps is obscured and the curve has only one minimum.

CONCLUSIONS

Factors governing use of surfactants in hot caustic extraction for reduction of pulp resin were studied. Performance of various classes of reagents were examined in relation to their structures in order to determine optimum surfactant composition for use under a variety of process conditions. Confirming earlier findings, it has been shown that differences exist in the behavior of coniferous and cottonwood pulps. Further, for any nonionic base material there is an optimum ethylene oxide content; the amount of resin removed depends on ethylene oxide content and on level of addition; and preferred additives are ether-linked nonionic surfactants.

Four hydrophobic base compounds—tridecanol, nonyl-, dodecyl-, and dinonyl phenols were examined over a range of ethylene oxide content from 60 to 80%. In each case it was found that the optimum ethylene oxide content was approximately 75% at 140°C., but that the absolute resin levels and hence the efficiencies of these bases were different. The optimum ethylene oxide content for any base is modified both by level of addition and temperature. At low levels of addition the performance is the resultant of the added surfactant and the resin soaps formed by caustic, while at higher levels the surfactant predominates and a lower per cent ethylene oxide is required. The optimum ethylene oxide increases with process temperature, but the minimum final resin level was found at temperatures between 90 and 120°C.

Deresination is a rapid process at all temperatures between 60 and 160°C. While residual resin levels change, the time to attain that level is virtually constant and independent of temperature.

A mechanism of deresination in hot caustic extraction has been proposed. It is considered that the primary process is the formation of resin soaps *in situ* by the action of the caustic on free acid resin components. This breaks up resin aggregates and aids the second phase which is dispersion of the remaining resin under the action of thermal agitation and the emulsifying action of the added surfactant. Saponification of resin esters does not appear to be a significant factor in dispersion, but may occur with the emulsified and suspended resin thereby minimizing reprecipitation.

As is well known, the behavior of hardwood resin depends greatly on the degree of seasoning and also on preliminary treatments. With cottonwood pulp made from nonseasoned wood the final resin level is independent of the per cent ethylene oxide in the surfactant, but after seasoning a 65% ethylene oxide content was found to be optimum. However, residual resin in cottonwood pulps that have not received special processing is considerably higher than with coniferous pulps regardless of the caustic extraction conditions.

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Continuous Pulping of Wheat Straw for Corrugating Media

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Rapid continuous pulping of wheat straw was investigated as a technique for the manufacture of corrugating board. Variables included chemical concentration, dwell time, steam pressure (temperature), and the pulping chemicals caustic soda, caustic soda-sodium sulfite, and caustic soda-sodium sulfide. For semicommercial-scale pulping 6% caustic soda, based on straw, 75 p.s.i. steam (160°C.), and 8 min. dwell-time were used. The refined straw pulp was used alone and in a blend with boxshop clippings to make 9-point boards on a fourdrinier machine. The boards were fluted, combined, and fabricated into shipping containers in a commercial plant. Component materials and test boxes were evaluated with the cooperation of manufacturers of straw corrugating. The wheat straw pulp prepared under continuous conditions proved satisfactory for the production of corrugating medium.

AUTOMATION and continuous processing are essential to the success of many industrial operations, largely by contributing to economy and to sustained production of uniform quality. Manufacture of corrugating media from wheat straw is no exception. If wheat straw is to continue as a raw material for the production of 9-point board in the United States, means must be developed to improve the economic position of straw among the cellulosic fibrous raw materials. That wheat straw makes quality corrugating media is undisputed; however, a variety of factors, largely economic, has resulted in decreased use of wheat straw for pulping. These factors include farming practices, distance of existing pulp mills from straw sources, straw storage, and obsolescence of processing operations through the pulping stage. Continuous pulping with lower man-power requirements might compensate for some of the apparent disadvantages.

The discontinuance of straw pulping in small mills, the shift from straw to wood or to reclaimed paper and containerboard in others, and the failure to refurbish strawboard mills emphasize the need for drastic improvements in straw pulping technology. Bale-breaking and straw chopping, charging of digesters, batch cooking, and batch refining are operations that might profitably be improved. Should any be made continuous, greater productivity per unit of manpower expended might be realized. Normally, continuous processing avoids the multiplicity of digesters needed in batchwise treatments to keep cylinder and fourdrinier machines running. In addition, operational and maintenance expenses can usually be minimized.

The concept of continuous pulping of agricultural residues is not new. Processes, such as the Celdecor-Pomilio, the Huguenot, and the Morley, have been used in Europe and elsewhere for several years (*1*). These processes generally are slow; that is, dwell times are long, and pulping is performed at or only slightly above atmospheric pressure. The recent trend in the United States has been to use higher steam pressure, to reduce dwell time, and to shorten pulping periods so that productive capacities can be increased. In turn, the investment and operating costs per unit of pulp produced will be lowered.

Upon request of the Northern Laboratory continuous pulping was the major topic on the program of the 1956 spring meeting of the TAPPI Agricultural Fibers Committee. Subsequently, a task group of the Committee met to explore possibilities for implementing a research program on continuous pulping. These deliberations led to a study of continuous pulping of wheat straw and to experimental production of 9-point corrugating media on a semicommercial scale. Portions of the program were conducted at the Northern Laboratory and other portions at the manufacturing and fabricating facilities of industrial companies.*

Before beginning the work on continuous pulping, the Northern Laboratory conducted a detailed study on 15-min. (exclusive of warmup and blowdown time) batchwise pulping of wheat straw with caustic soda (*2*). This experiment was statistically designed to determine the influence of the strength of pulping chemical and of the pulping temperature on the quality of the final corrugating board. Results of this earlier study provided a basis for selecting conditions for initial trial in continuous pulping experiments.

The study on continuous pulping comprised three phases: (1) study of process variables, involving type and strength of pulping chemicals, dwell-time (cooking), and steam pressure (or digestion temperature); (2) production of straw pulp and 9-point corrugating board from 100% straw pulp and from a 50:50 blend of pulps from straw and reclaimed containerboard on a semicommercial scale; and (3) evaluation of the experimental media by use in a commercial boxshop and by customary laboratory tests on media and fabricated containers.

EXPERIMENTAL

Equipment

Pulping equipment consisted of an 18-in., 3-tube, Pandia Chemi-Pulper† continuous digester complete with a 7 1/2-in. screw feeder, rotary discharger, variable speed drives, and controls. These facilities have already been described elsewhere (*3*).

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† This and other references to companies or commercial equipment by specific names are made for clarity and conciseness of presentation and are not to be construed as endorsements or recommendations by the United States Department of Agriculture.

Table I. Continuous Pulping of Wheat Straw for Corrugating Board: Conditions, Yields, and Some Characteristics of Handsheets (H) and Machine Sheets (M)

Run no.	Chemical used,[a] %	Dwell-time, min.	Steam pressure, p.s.i.	Washed yield, %	Pulp retained on 10-cut screen,[b] %	Strength characteristics at 600 ml. °S.-R. CMT f (H), lb.	CMT f (M), lb.	Burst factor (H)	Burst factor (M)	Breaking length (H), m.	Breaking length (M), M.D., m.	Tear factor (H)	Tear factor (M), C.D. m.	Basis weight (M), lb./M sq. ft.	Density (M), g./cc.	Caliper (M), 0.001 in.
Caustic Soda Pulping																
1	4.2	5	75	67.0	28.0	43	51	20	17	3790	4410	76	46	29.0	0.37	15.0
2	4.85	11	100	64.1	36.9	48	58	21	20	4120	4650	73	57	27.0	0.40	12.9
3	5.45	8	100	57.5	15.9	75	80	39	30	6110	6680	57	61	27.6	0.50	10.6
4	5.58	11	100	65.2	18.0	74	77	35	29	5970	6730	57	60	27.4	0.50	10.4
5	6.1	5	100	63.2	20.7	71	77	34	39	5920	6640	61	64	27.4	0.49	10.8
6	6.35	5	75	65.9	24.8	64	72	30	25	5260	6070	63	58	27.4	0.46	11.4
7	6.37	5	75	57.1	9.2	77	80	39	32	6310	7160	64	66	28.2	0.51	10.6
8	6.25	8	75	63.9	14.8	76	84	37	30	6070	7060	64	63	27.0	0.50	10.4
9	6.20	11	100	56.1	12.0	76	91	42	36	6920	7300	54	71	28.0	0.56	9.5
10	6.22	11	75	62.5	10.5	74	88	40	33	6210	7400	60	57	27.4	0.54	9.7
11	6.45	11	75	53.0	2.5	73	100	43	39	6540	8150	57	58	27.0	0.59	8.8
12	6.60	11	100	59.0	4.9	76	94	42	38	6350	8060	64	58	26.5	0.59	8.7
13	7.28	11	120	62.2	8.0	76	102	44	41	6830	7820	57	65	28.5	0.61	9.0
14	7.9	2.5	75	64.4	8.6	85	86	39	32	6540	7110	54	71	26.5	0.53	9.6
15	8.25	8	75	49.0	1.7	72	108	47	42	7000	8300	61	55	28.0	0.70	8.8
N–1[c]	6.0	15	40	67.1	20.2	71	92	35	27	5920	5880	60	60	31.0	0.57	10.5
N–2[c]	6.0	15	40	66.1	9.2	75	94	37	30	6070	7200	51	55	29.0	0.63	8.8
N–3[c]	6.0	15	40	66.4	18.3	77	85	36	28	6020	6350	55	61	28.0	0.60	9.1
N–4[d]	6.0	15	40	67.2	9.7	73	81	34	32	6160	6830	47	53	29.3	0.58	9.5
Caustic Soda—Sodium Sulfite (1:1) Pulping																
16	6.1	11	100	64.5	39.1	63	72	28	26	5400	5880	61	65	28.2	0.48	11.3
17	8.4	11	100	(83.0)	35.7	56	60	26	24	4930	5690	70	71	28.0	0.43	12.5
18	8.85	11	75	57.3	12.2	81	94	40	35	6450	7490	52	55	28.2	0.57	9.5
Caustic Soda—Sodium Sulfide Pulping (2:1)																
19	3.52[e]	11	100	58.0	11.8	79	93	42	37	6730	7390	50	53	27.6	0.59	9.0
20	4.10[e]	11	100	59.2	6.3	53	99	41	42	6730	7960	48	65	28.0	0.63	8.5
21	4.22[e]	11	75	64.5	12.4	74	95	39	38	6590	7440	52	53	28.5	0.59	9.3

[a] Basis dry straw. [b] After 10 min. in washer-beater set at 0.003 in. [c] Reference pulps made in batch cooker at Northern Laboratory to appraise straw quality. [d] Straw used in semicommercial-scale operations. [e] As Na_2O. Factor to calculate percentage of total chemical = 1.28. [f] CMT = Concora medium test.

To accommodate straw the usual hopper for wood chips was replaced by a combination hopper and compaction screw. In addition, a variable-speed rotary feeder to meter chopped straw, a mixer for treating straw with water or chemicals, and a belt conveyor were provided. A Nyblad 3-knife cutter was used for chopping straw. Other facilities for the preparation of pulps included a live-bottom blow tank to collect material from the discharger, a 24-in. double-disk refiner, an agitated stock tank, and a vacuum washer for making pulp wet laps.

The facilities for refining pulps and making 9-point board were those at the College of Forestry, State University of New York at Syracuse. They included a 52-in. fourdrinier machine (18–450 f.p.m.), a 500-lb. capacity, 8-ft. Hydrapulper, a 36-in. disk refiner, a 1000-lb. beater, a finishing jordan, and a pulp screen.

Straw

Wheat straw used in the first phase of this study was obtained from a supplier in Montreal, Quebec. The straw used in the semicommercial-scale operations was obtained from southeastern Michigan and was representative for that area.

Bale samples, as well as composites of grab samples collected during the pulping studies, were evaluated by a batch cooking procedure. Cooking at 140°C. for 15 min. with 6% caustic soda (basis straw) was used to prepare reference pulps. Customary beater evaluations and characterization of 9-point board prepared from pulps at 600 ml. °S.R. (300 ml. C.S.) on a midget fourdrinier machine were performed. Other than the Concora medium test, (CMT), the procedures were those approved by TAPPI.

Study of Variables

Cut straw was metered continuously into the mixing tank where water was added to wet the straw thoroughly. The wet straw was conveyed to the compacting screw, which in turn discharged into the screw feeder. Excess water and some dirt were removed through weep-holes in the tapered zone of the screw feeder. Consistency of the resulting compressed mass was about 55%. The compressed straw formed a plug to resist the internal pressure of the digester. Steam and chemicals were introduced immediately after the mass passed through the plug pipe. The straw and chemicals were conveyed through the three digester tubes by spiral flights, and discharged through a special blow valve to the live-bottom cyclone collector. From the blow tank the cooked straw was passed through the 24-in. refiner set to provide only a brushing action and then to the sewer or to the agitated stock tank. Sufficient time was allowed to clear the system of any pulp from the prior run and to establish stabilized conditions before diverting the pulp from the sewer to the stock tank. Pulp yields were calculated from consistency values and tank contents collected in known periods of time. Samples removed for evaluation were washed and dewatered to about 35% solids content before being sent to the Northern Laboratory. Testing procedures were the same as those used in evaluating the reference pulps prepared from the straw samples.

Pulping chemicals used were caustic soda, caustic soda and sodium sulfite in equal proportions, and caustic soda and sodium sulfide in proportions of 2:1 by weight. Percentage strength of chemical was based on the dry weight of straw used. Steam pressures within the digester were 75, 100, and 120 p.s.i., corresponding to temperatures of 160, 170, and 177°C., respectively. Lower steam pressures were not used because nearly 75 p.s.i. (160°C.) was needed for effectively blowing pulp through the discharge valve and delivering it to the live-bottom collector. Dwell-time, i.e., the total time required for passage of straw through the 3-tube unit, ranged from 2.5 to 11 min. Liquor-solids ratios, by weight, varied from 2.1:1 to 7.5:1, and chemical strength ranged from 4 to 14%

Table II. Continuous Pulping of Wheat Straw and Preparation of 9-Point Corrugating Media on a Semicommercial Scale: A Summary

Pulping

Pulping liquor, caustic soda	12.4 g. NaOH per liter
Liquor applied at mixer	1.2% NaOH basis straw
Liquor applied at digester	4.8% NaOH basis straw
Total liquor	6.0% NaOH basis straw
Liquid:solids ratio, not including condensate	4.95:1
Dwell-time	8 min.
Steam pressure	75 p.s.i.(160°C.)
Straw input, dry	4370 lb.
Pulp yield, wet	11,753 lb.
Operating time	13 hr. 12 min.
Solids in pulp	25%
Feed rate	351 lb. per hr.
Yield, dry	2940 lb.
Yield, overall	67.1%

Refining

100% straw pulp	Clippings
Disk refining to 300 ml. C.S.	Slushed in Hydrapulper
Screened on 12-cut screen	Brushed in beater to 125 ml. C.S.
Freeness after screening	335 ml. C.S.
	Beater-washed to 140 ml. C.S.

Composition of Blend

100% straw pulp at 335 ml. C.S.	48%
Clippings pulp at 140 ml. C.S.	46%
Kraft pulp, unbeaten	6%

Machine Operation

100% straw pulp	Blend
Freeness at headbox, 275 ml. C.S.	Freeness at headbox, 220 ml. C.S.
Consistency at headbox	Consistency at headbox
1.25% pH, 8.0	1.3-1.7%
Wire speed 150 f.p.m.	Wire speed 100 f.p.m.

Number of driers	17
Steam pressure in driers, p.s.i.	30

based on weight of dry straw. Not all conditions were used with any one pulping chemical (Table I).

Semicommercial Pulping and Boardmaking

Following the characterization of pulps, the conditions selected for semicommercial-scale pulping were 8 min. dwell-time, 6% caustic soda, and 75 p.s.i. steam pressure (160°C.). A portion (about 20%) of the required pulping liquor was used to pre-impregnate the cut straw before it reached the digester. This amount was controlled so that no loss occurred at the weep-holes of the screw feeder. The balance of the chemical and the steam was added beyond the plug pipe. Upon completion of the continuous pulping the unrefined pulp collecting in the agitated stock tank was pumped to the vacuum washer where the pulp was made into wet laps for shipment. Nearly 4400 lb. of straw, dry basis, were pulped without difficulty in a run which lasted more than 13 hr. Frequent checking of the straw input and regulation of the liquor flow rate during the pulping operation assured that the straw feed rate was kept within 5% of the overall average, and that the straw-to-chemical ratio was maintained constant.

The pulp was reslurried in a Hydrapulper, was refined at a 4.65% consistency in a 36-in. disk refiner to reduce freeness to 300 ml. C.S., and then was screened on a rotary vibrating screen, the rejects (0.35%) were discarded. About 75% of the straw pulp was processed into an all-straw 9-point corrugating medium. No difficulty was encountered on the fourdrinier machine (wire speed 150 f.p.m.). For the blend, reclaimed containerboard (boxshop clippings) was slushed in the Hydrapulper and then washed to remove starch. Some unbleached kraft pulp was added to this washed pulp to increase its freeness before blending with the straw pulp. The final blend containing 48% straw pulp, 6% kraft pulp, and 46% reclaimed containerboard and having a freeness of 220 ml. C.S. was run at approximately 100 f.p.m. on the fourdrinier. Both the all-straw medium and the blend were calendered. Approximately one-half ton of each type of board was shipped to the commercial boxshop of one of the cooperating mills for practical tests. Character of the machine furnishes and conditions of the fourdrinier operation are shown in Table II.

Samples of the wet lap, machine furnishes, and the final 9-point boards were sent to the Northern Laboratory for evaluation.

Boxshop Operations

In the boxshop tests "A" and "C" flute boards were made with both the all-straw medium and the 48:52 blend. Commercial 50-lb. liner was applied as double facing. The regular starch adhesive was used without modification for bonding the facings to the fluted medium. Both experimental media performed equally well on the commercial corrugators at machine speeds up to 340 f.p.m. Samples of the components and of the combined boards were distributed among the cooperating group, and the remainder of the boards were used in fabrication of 14 by 14-in. test boxes. Samples of these boxes were also distributed among the cooperators for testing.

RESULTS AND DISCUSSION

Tests conducted at the Northern Laboratory on the straws used in the study of variables and in the semicommercial pulping showed that the two straws were not significantly different in characteristics. Yields on pulping for 15 min. at 140°C. with 6% caustic soda were nearly the same. Physical characteristics including CMT values for machine boards were comparable. Thus, any significant differences that might show up between the study of variables and the production phase should not be attributed to differences in the straw.

Pulping Variables

From the data collected (Table I) in pulping continuously with caustic soda under a variety of conditions, the minimum amount of chemical required for satisfactory pulping appears to be about 5.5%, basis straw solids. This conclusion is supported by results obtained for run no. 3 in which the chemical strength was 5.45%, the steam pressure 100 p.s.i. (170°C.), and the dwell-time 8 min. After the 10-min. treatment in the beater-washer, this pulp contained approximately 15.9% material retained on a 10-cut screen. This value was within the range (9.2 to 20.2%) for screenings for the reference pulps (N1–N3) prepared with straw from the same lot. Strength characteristics improved markedly at this level (5.45%) of caustic soda. Use of caustic soda up to 8.25% caused decreases in the amount of pulp retained on the 10-cut screen, the value dropping to 1.7% at the 8.25% NaOH level. With the lower retention values (1.7–8.6%) CMT values of machine sheets ranged from 86 to 108 lb., although handsheets failed to exhibit a similar improvement. Burst factors and breaking length also failed to respond to the same degree of improvement. Although not entirely consistent with changes in pulping conditions,

Table III. Some Strength Characteristics of Experimental Corrugating Media and Combined Double-Faced Boards as Determined in three Cooperating Laboratories

Laboratory	Corrugating medium: Basis weight, lb./M, sq. ft.	Caliper, 0.001 in.	CMT[a] lb.	Burst, p.s.i.	Ring crush, 6 × 1/2 in. M.D., lb.	Ring crush, 6 × 1/2 in. C.D., lb.	Combined board "A" Flute: Flat crush, p.s.i.	Puncture (Beach),	Burst, p.s.i.	Pin adhesion, lb.	Combined board "C" Flute: Flat crush p.s.i.	Puncture (Beach),	Burst, p.s.i.	Pin adhesion, lb.
						100% Straw Pulp								
1	32.2	9.0	80	41	56	50	43.7	217	212	41	52.7	220	214	58
2	32.0	...	89	46	66	56	39.6	248	...	...	47.0	215	...	...
3	31.7	8.8	82	37	22[b]	16[b]	38.6	225	199	...	48.0	224	190	...
						Blend Straw Pulp and Reclaimed Boxboard								
1	30.3	8.8	76	46	64	47	37.0	225	194	46	43.2	226	210	55
2	30.1	...	80	52	58	48	33.8	222	...	...	43.8	245	...	...
3	30.2	8.5	74	43	20[b]	16[b]	34.0	226	225	...	48.0	221	216	...
						Commercial Medium, Straw and Reclaimed Boxboard								
3	29.0	9.1	68	40	19[b]	12[b]	...	...	...	...	35.0	200	265	...

[a] CMT = Concora medium test.
[b] Specimens 2 × 1/2 in.

the strength properties generally improved with the more rigorous conditions employed.

Within the range of caustic soda concentration from 6.1 to 6.6% (basis straw) no significant change in strength characteristics could be attributed to temperature or to dwell time. The higher crush values (CMT) were associated with those pulps having lesser amounts of material retained on the 10-cut screen after the beater-washer treatment. When a dwell time of 5 min. was used, closer agreement in strength characteristics for pulps was obtained between runs nos. 7 and 5 at 75 and 100 p.s.i., respectively, than between runs nos. 7 and 6 which were duplicates with respect to dwell-time and steam pressure.

All pulps prepared with a strength of caustic soda greater than 5.45% had properties comparable to or better than those of the reference pulps prepared by batch cooking of the same straw with 6% caustic soda.

The caustic soda-sodium sulfite treatment was less effective than the caustic soda alone for pulping. To achieve characteristics in the pulps comparable to those found for pulps prepared with 6.1 to 6.6% caustic soda, a chemical strength of 8.8% was required.

The kraft-type chemical was effective in pulping straw for use in corrugating media. The data indicate that a total chemical strength (caustic soda and sodium sulfide combined) above 4.5% will yield pulps of acceptable quality; however, the odor, greater complexity of cook liquor preparation, and greater expense would rule against its use.

This study has emphasized the importance of the manner in which cooking liquor is added. Initial attempts to introduce cooking liquors at the same point as when wood chips are used gave rise to nonuniformity in pulps. Homogeneity was appraised after pulps were treated in a washer-beater set at 0.003-in. clearance to remove residual chemicals and to initiate defiberizing. Samples removed from the beater-washer and passed over a 10-cut flat screen showed the presence of excessive amounts of coarse material—up to and more than 50% in trial runs while batch-cooked pulps displayed about 20% or less. Lignin contents of the screened pulps and screenings supported the belief that the screenings had been cooked to a lesser extent than that fraction of the straw represented by the screened pulp. Ultimately the amount of screenings in pulps dropped to about 3%. This nonuniformity in pulps was corrected by wetting the straw before it was introduced into the digester.

Semicommercial Pulping and Boardmaking

After exploratory studies were completed, minor adjustments were made in the clearance between the rotor and shell of the screw feeder. This change made it possible not only to handle without difficulty straw thoroughly wetted by water but also to handle straw that had been wetted with caustic cooking liquor. Thus, a portion (20%) of the cooking liquor was added to the straw before it was introduced into the compaction screw. This addition further facilitated distribution of the pulping action throughout the mass of straw as judged by the low value (1.7%) of the screenings determined after the beater-washer treatment on a sample. These screenings were ultimately removed from the pulp by the rotary vibrating screen. A summary for semicommercial-scale pulping and boardmaking is presented in Table II.

Boxshop clippings containing 9-point strawboard were used to simulate commercially reclaimed corrugated containers. Selection of clippings for this investigation was based on the belief that their behavior would be like that of used containers and that clippings would not require cleaning operations normally associated with use of reclaimed containerboard. Cleaning of commercially reclaimed board under pilot-plant conditions would have been difficult if not impractical. Initial freeness of the repulped clippings was 125 ml. C.S. and this freeness was raised to 140 ml. C.S. by washing in the beater.

The addition of the unbleached kraft pulp was only for the purpose of improving freeness of the blend before running on the fourdrinier machine. Six per cent of the unbeaten southern pine kraft pulp was sufficient to raise the freeness to 220 ml. C.S. Even at this level the desired amount of water for optimal formation could not be added on the machine. Some sticking was experienced at the presses. Although the most efficient machine operation could not be achieved for the furnish from the blend of repulped clippings and kraft and straw pulp, the strength characteristics of the resulting medium exceeded those of the commercial medium used for comparison (Table III).

Table IV. Compression Loads and Deflection for 14 × 14 × 14-in. Boxes Fabricated from Corrugated Board Containing Experimental Media

Laboratory	Top-to-bottom Load Minimum, lb.	Top-to-bottom Load Maximum, lb.	Top-to-bottom Load Average, lb.	Top-to-bottom Deflection, in.	End-to-end Load Minimum, lb.	End-to-end Load Maximum, lb.	End-to-end Load Average, lb.	End-to-end Deflection, in.
"A"-Flute Corrugations								
100% straw pulp								
R	770	870	817	0.66	950	1020	990	0.53
S	710	900	809	0.62	910	1120	1038	0.50
T	740	750	745	...	920	1006	952	...
Blend: 48% straw pulp								
R	785	945	850	0.72	820	930	908	0.50
S	620	860	761	0.66	870	1170	980	0.43
T	552	746	637	...	746	892	801	...
"C"-Flute Corrugations								
100% straw pulp								
R	760	860	808	0.68	990	1100	1036	0.40
S	665	780	735	0.58	910	1120	1063	0.37
T	634	740	679	...	892	1156	997	...
Blend: 48% straw pulp								
R	660	760	705	0.70	760	1060	935	0.46
S	615	740	693	0.56	690	970	824	0.32
T	610	710	657	...	890	1062	991	...

The results of the evaluations show the pulping conditions selected were satisfactory; namely, 8 min. dwell-time, 75 p.s.i. steam pressure (160°C.), and 6% caustic soda (basis straw). Physical characteristics particularly the CMT values, indicate that the pulp prepared by continuous processing and converted to 9-point board on the small fourdrinier machine (9-in. trim) at the Northern Laboratory was comparable with the experimental all-straw boards used in the boxshop tests, and with pulp prepared from the same lot of straw by batch cooking for 15 min. at 140°C. with 6% caustic soda.

Characteristics of combined boards containing the experimental media were also equal to or comparable with those of the commercial material. Pin adhesion tests conducted in one of the cooperating laboratories showed that laminating of the liner faces to the fluted experimental media was adequate for both the all-straw board and the blend.

Box Fabricating and Testing

Both experimental media were fluted and combined in the box plant as "A" and "C" flute boards as satisfactorily as the regular commercial media. Adjustments made in corrugator operation were normal for fluting and gluing.

Results of testing uncombined materials, combined corrugated boards, and fabricated boxes by the mill laboratories and by the Northern Laboratory show some variation in values for the uncombined media. Flat crush values for combined "A" and "C" flute boards were slightly greater when the corrugating medium was from 100% straw pulp than from the blend. Values for burst and puncture were in essentially the same ranges regardless of composition or type of fluting.

Results of the box compression tests disclose that the data (Table IV) are more consistent for the all-straw corrugating board than for those prepared from the blend. Further, the results are more favorable for the boxes fabricated from "C"-flute boards than from "A"-flute boards. While there is considerable variation in results for the all-straw and the straw-clippings blend, data are sufficient to show that high quality corrugating board and boxes can be prepared from continuously pulped wheat straw. It is reasonable to believe that with additional study on reprocessing boxshop clippings and on the combining and fabricating, the higher strength characteristics could be replicated without difficulty.

As previously observed, the 100% straw pulp was satisfactory to prepare 9-point corrugating media with characteristics comparable to those of a commercial straw blend now in use. Combining defects were less obvious in "C"-flute specimens than in "A"-flute boards. Use of the all-straw medium favored high combining efficiency, exceeding 100%. Further study on how to prepare a straw pulp-clippings blend might provide improvements in physical properties of the medium and in compressive strength of boxes fabricated from it.

SUMMARY

This study has demonstrated on a semicommercial scale that wheat straw can be pulped with caustic soda by a rapid continuous technique to produce pulps suitable for manufacture of corrugating media and shipping containers.

Based on this study the contractor has prepared cost estimates for hypothetical strawboard mills that might be located in regions of high straw production. The economics of producing 9-point corrugating board by this process in the United States is being investigated by the Agricultural Research Service.

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The Efficiency of Mechanical Pulping Processes

GEORGE E. R. LAMB

The mechanical energy required to produce unit area of surface in wood has been measured. The results are of the order of 10^5 ergs per sq. cm. and indicate that the efficiencies of mechanical pulping processes may be of the order of 20%, whereas previous estimates placed these efficiencies in the order of 10^{-3}%. The relation of the results to these previous estimates is discussed.

THE EFFICIENCY of mechanical pulping and beating processes has been discussed many times. There is little doubt left about the fact that of the energy input to a commercial grinder, over 99% appears as heat. The efficiency is thus apparently less than 1%. The high temperatures produced in the grinding zone no doubt contribute to the development of the qualities desired in the pulp, but even then, most of the energy finds itself heating the cooling water rather than the wood.

Campbell (*1*), and subsequently Van den Akker (*2*) estimated this efficiency by considering the energy absorbed in the formation of the surface of pulp. Pulping can be regarded as an increase in the surface of wood. A log may weigh 10 kg. and have a surface of 1 sq. m. When reduced to pulp it may have a specific surface of as much as 10 sq. m. per g., an increase of a factor of 10^5. Van den Akker (*2*) estimated the surface energy of beating by considering the work required to peel a fibril from a fiber. He assumed that the surface thus produced separated adjacent cellulose chains by breaking the hydrogen bond cross-links. If each anhydroglucose unit occupies an area $8.35 \times 5.12 \times 10^{-16}$ sq. cm. and the dissociation energy of hydrogen bonds is 5 kcal. per mole, the surface energy, assuming one hydrogen bond to be associated with each anhydroglucose unit, is 44 ergs per sq. cm. This value is in very close agreement with the results obtained by Stamm (*3*) in his estimates of the work of cohesion of cellulosic materials from absorption data.

In an idealized process consuming about 50 ergs per sq. cm. of surface and producing pulp having a specific surface of about 10 sq. m. per g., the power consumption would be about 10^{-2} hp.-days per metric ton. Present commercial processes use energies of the order of 10^2 hp.-days per ton and might therefore be considered to have efficiencies of the order of 10^{-4}. The bulk of the waste heat has been shown (*4*) to be produced in the repeated deformation of the wood by the grindstone grits which precedes the removal of a fiber. No experiments, on the other hand, have ever been performed to measure the actual separation energy for fibers.

The purpose of the present article is to present evidence indicating that idealized pulping energies based on the surface tension of the solid being pulped may actually be over-idealized.

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EXPERIMENTS AND RESULTS

The experiments were intended to simulate an idealized pulping operation, namely the peeling of individual fibers. In such a process, energy losses due to friction or to compression are avoided, or at least reduced. In practice, individual fibers are too small to handle without considerable difficulty, so thin wood wafers were used instead. These wafers were cut on a microtome in a plane tangential to the log. The wood chosen for the experiments was Norway Spruce, *Picea abies* (L.) Karst. The log, after being felled, was kept immersed in a 50% ethanol solution. It was found that a wafer thickness of about 120 μ was most satisfactory, this being equivalent to about four fiber diameters. The microtome would not cut thicker pieces, and a thickness approaching that of a single fiber meant that many fibers would be cut open. The wafers were torn down the center, as shown in Fig. 1, rather like paper in a tear test. The tear was started by splitting about 3 cm. of the end of the wafer and the slit ends were clamped in the "A" cell jaws of an "Instron" tensile testing machine, which provided the tearing force F and recorded it on a chart. The mode of tearing was essentially equivalent to peeling of the fibers in the zone of failure, while the remainder of the wafer provided a backing for ease of handling.

To obtain the energy consumed per unit surface, direct measurements of both the energy and surface were made. The energy was simply obtained from the record of the force F by measuring the area under the force-displacement curve given by the Instron.

The surface measurements presented a problem: it was obviously a delicate matter to measure a surface only 100 μ wide, and to assume that the surface was a plane perpendicular to the plane of the wafer would have been too rough an approximation. After the tests, therefore, the wafers were embedded in polybutyl methacrylate and sections were cut at right angles to the length of the wafer. The sections, mounted on slides, were placed in a projection microscope and a greatly magnified image of the cross section of the zone of failure was thrown on a screen, where the surface of failure was seen in profile, as in Fig. 2. The length of this profile was measured. Sections were cut every 2 or 3 mm. along the wafer, so that the average of the profile lengths multiplied by the length of the peeled zone could be taken as a good approximation to the surface area. Figure 3 shows that a definite, linear relationship exists between the surface areas measured in this fashion and the energy consumed, and that the ratio of these two quantities was thus a surface energy term. The tangent of the curve in Fig. 3 was 1.4×10^5 ergs per sq. cm. This was some three orders of magnitude larger than the work of cohesion values of Campbell and Van den Akker, and

Fig. 1

equivalent to 2.3 hp.-days per ton for a pulp with 1 sq. m. per g. of specific surface.

Ingmanson and Whitney (*5*), having measured the specific surfaces of pulps by a filtration resistance method found that a spruce-fir groundwood with 140 ml. Canadian Standard freeness had a specific surface of 6.3 sq. m. per g. On the above basis, commercial production of the surface of this pulp would require a minimum of 14.6 hp.-days per ton. Since the actual energy consumption for pulps of 140 ml. freeness is about 70 hp.-days per ton the grinding efficiency appears to be about 20%. It is, therefore, appropriate to consider the validity of our measurements.

Estimates of Errors

It is possible that, if the true surface area were greater than the measurements showed, or if the energy measured were to include losses which were irrelevant to the formation of surface, an excessive surface energy would result. Figure 2 shows a portion of a typical slide used in the surface measurements. It can be seen that the outline of the failure surface follows closely the cells' middle lamellae, with little or no fibrillation. Now, the specific surface of a chemical

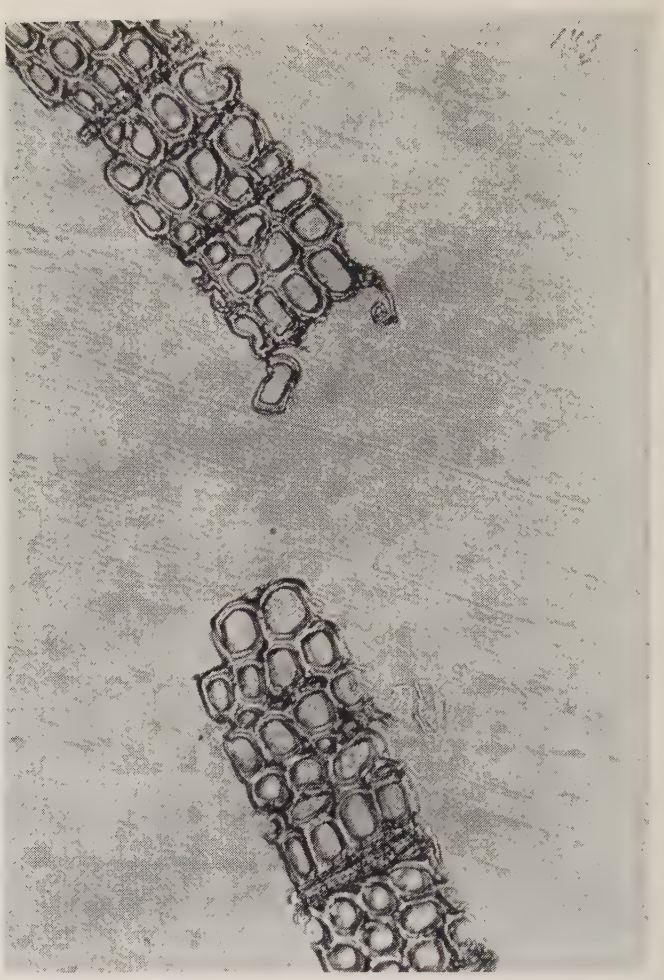

Fig. 2. Cross-section of failure surface

pulp (i.e., a pulp consisting of whole fibers) as measured by permeability, silvering, or gas adsorption methods is of the same order of magnitude as that derived from a simple model. For instance, assuming fibers to be continuous, cylindrical hollow tubes of 20 μ o.d. and 16 μ i.d. and density 1.5 g. per cc. the specific surface is 0.37 sq. m. per g. The observed specific surface varies with the method of measurement, but all agree on a value of about 1 sq. m. per g. for sulfite pulps. Hazelton (*6*) has obtained 0.8 sq. m. per g. for spray-dried sulfite pulp by nitrogen adsorption, which is probably the most reliable method. If this included the lumen surface, the agreement with the model

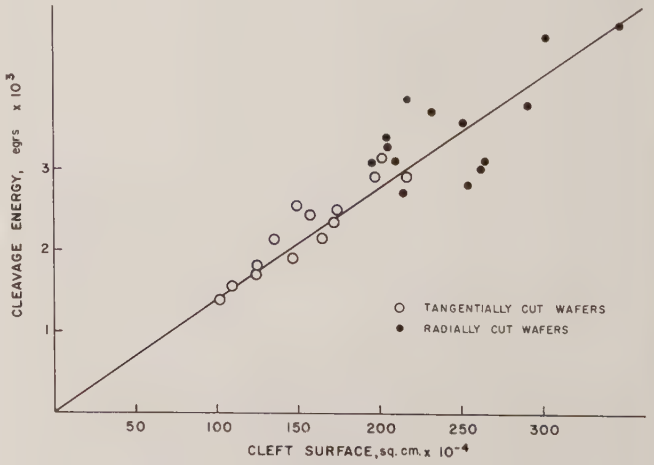

Fig. 3. Failure surface against work of separation

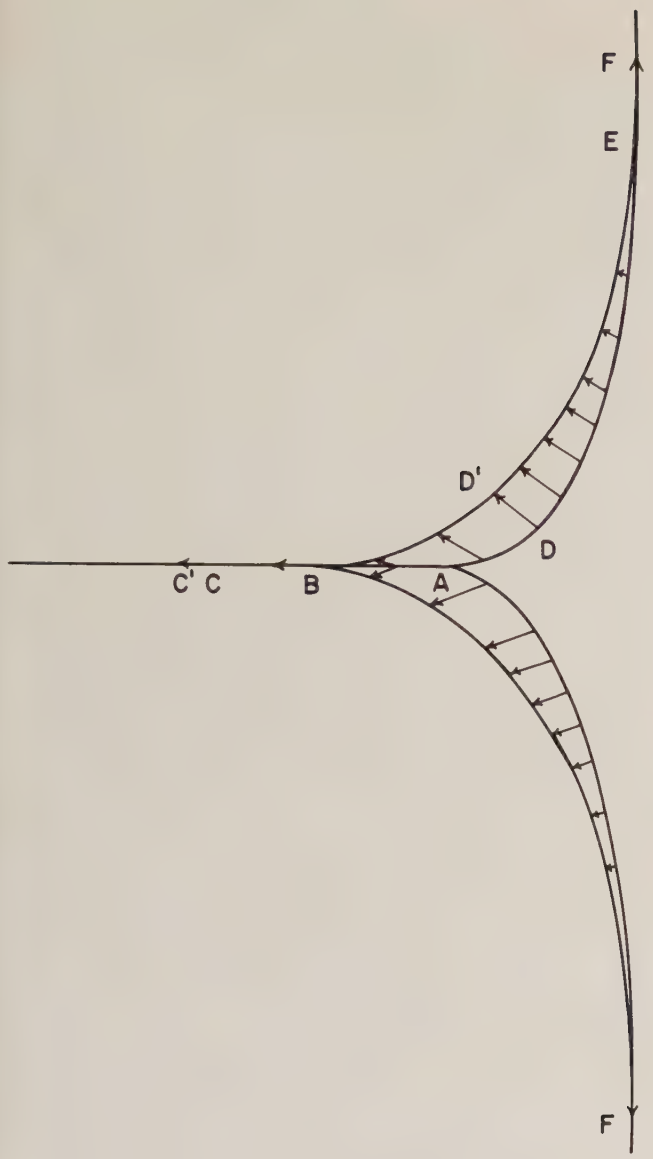

Fig. 4. Fast crack propagation

would be perfect: if not, the indication is that ignoring the submicroscopic roughness of the surface only introduces an error factor of about two. In our determinations the surface measured was essentially the geometrical outer surface of the fibers exposed by peeling and could, therefore, on the above argument, be assumed to be in error by a factor of not more than two.

The energy measured could include (a) losses due to stretching of the torn halves of the specimen by the tearing force F, (b) hysteresis losses in the bending of the specimen, and (c) kinetic energy losses due to rapid propagation of the crack. For convenience the losses were calculated per centimeter length of wafer.

In the first effect the strain energy W per cm. is given by

$$W = A \cdot s^2/2E \qquad (1)$$

where

s = stress, dynes per sq. cm.
E = Young's modulus, dynes per sq. cm.
A = $^1/_2$ × cross-sectional area of specimen, sq. cm.

The cross-sectional area of the specimen was about 10^{-2} sq. cm. The force F was several grams, and E was about 10^{11} dynes per sq. cm. W was thus of the

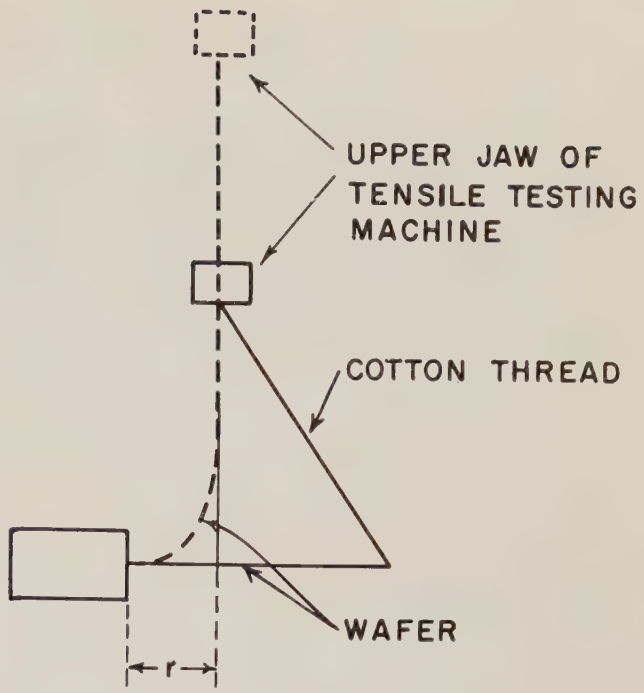

Fig. 5. Measurement of hysteresis loss

order of 10^{-3} ergs per cm. and was immediately seen to be negligible when compared with the total work which was $= F \cdot g \approx 10^3$ ergs per cm.

The effects of hysteresis and kinetic energy losses, on the other hand, had to be measured.

Figure 4 shows how the hysteresis loss occurs. A straight portion of wafer at C finds itself, as tearing progresses, in the bent position D and later again in the straight position E. This bending and straightening does not occur reversibly but absorbs energy in hysteresis. This loss was determined by direct measurement. Wafers were fixed like cantilever beams and end-loaded as shown in Fig. 5. The loads were increased to various levels and then again reduced to zero. The hysteresis losses H were obtained from the loops which were recorded on the Instron chart. The distance r was measured and the curved portion of the loaded specimen assumed to be a quarter circle of

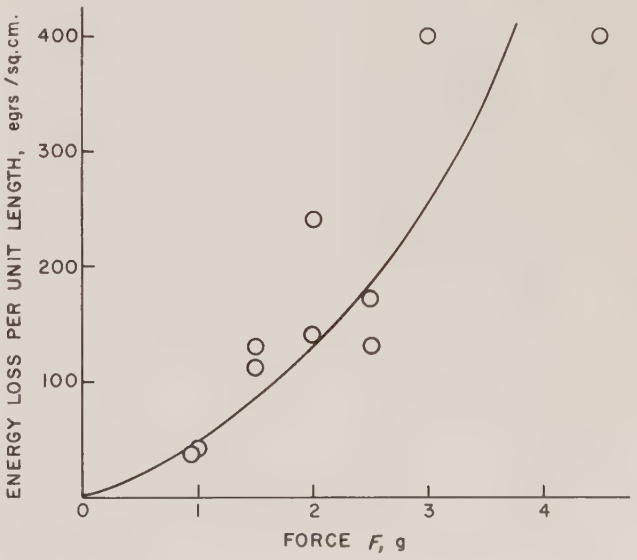

Fig. 6. Hysteresis loss per centimeter

radius r cm. The hysteresis loss per cm. was then

$$\frac{H}{1/4 \cdot 2 \cdot \pi \cdot r} = \frac{2H}{\pi \cdot r} \qquad (2)$$

and was known as a function of the load. The results are shown in Fig. 6. The loss varies from about 5% at a load of 1 g. to about 10% at a load of 4 g.

Kinetic energy losses occurred because the peeling was not continuous but proceeded in short jerks, the effect being more pronounced when the wood was dry. Reference to Fig. 4 will illustrate the mechanism; when the crack travels from A to B (this happens too quickly for the eye to follow) the torn halves of the

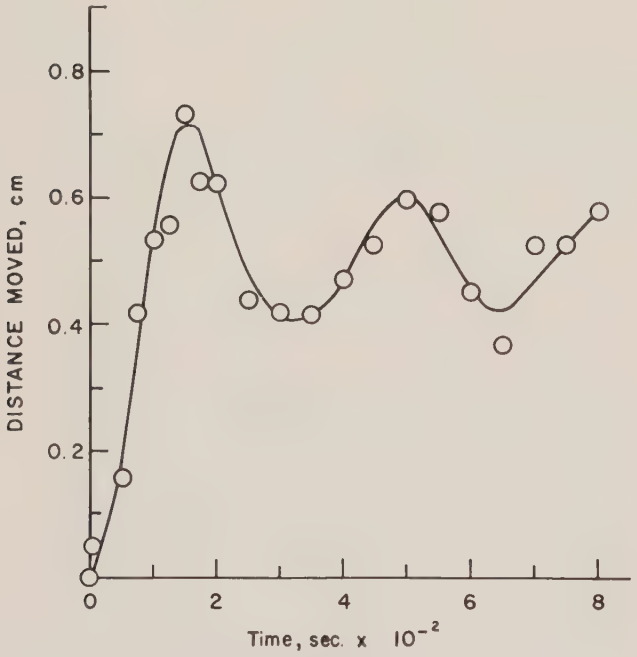

Fig. 7. Oscillations following fast crack propagation

wafer assume a smaller curvature under the reduced force F and points on the wafer move in the directions indicated by the arrows. The point moving with the greatest velocity is at D, where the tangent is approximately 45° to the horizontal. The torn halves vibrate about the final position $ED'C'$ before coming to rest and it is in these damped vibrations that the kinetic energy is dissipated. Moving pictures were taken at the instant when such a rapid crack increase took place. The camera took 2000 frames per second and the action was spread over about $1/10$ sec. Positions of point D are plotted against time in Fig. 7. The maximum velocity is about 64 cm. per sec. The crack traveled about 0.5 cm. taking a total energy of the order of 2×10^3 ergs. The whole wafer weighed 0.1 g. and, assuming for a first approximation that the velocity distribution along the wafer was uniform, it can easily be shown that the kinetic energy was

$$\frac{1}{3} \times \frac{1}{2} mv^2 = \frac{1}{6} \times 0.1 \times 64^2 = 68 \text{ ergs}$$

The error due to this loss was then only a negligible 3.3%. The results of Benbow and Roesler (*7*) confirm that kinetic energy losses account for a negligible fraction of the work of fracture, which for styrene was actually found to be about 10 times larger for slow running than for fast cracks.

The above considerations, therefore, indicate that the energy actually absorbed in the formation of interfiber surfaces, after taking account of the various losses inherent in the method, is of the order of 1.2×10^5 ergs per sq. cm. The results of other workers lend support to this conclusion. Benbow and Roesler (*7*) obtained 5 and 25×10^5 ergs per sq. cm. for the specific fracture energies of polymethylmethacrylate and polystyrene. It is worth noting that when the methacrylate fractures it does so along perfectly smooth surfaces, leaving no room for error in the area measurement. Rivlin and Thomas (*8*) obtained values for various rubber vulcanates ranging from 10 to 200 $\times 10^5$ ergs per sq. cm. Nordman (*9*), in an experiment designed to measure the density of hydrogen bonds in interfiber bonds in paper, measured the increase in scattering coefficient associated with the energy loss in cyclic loading of paper samples. He obtained 1.6×10^5 to 8.2×10^5 ergs per sq. cm. for the specific energy of separation of the fiber-fiber bonds. Nordman interpreted these values in terms of a surface density of hydrogen bonds, but this is hard to visualize since on Van den Akker's model 10^5 ergs per sq. cm. is equivalent to about 500 bonds per anhydroglucose unit. His result, nevertheless, confirms the view that mechanical production of surface is invariably brought about at an energy expense of the order of 10^5 ergs per sq. cm.

DISCUSSION OF RESULTS

The problem of accounting quantitatively for these specific surface energies is, for the moment, not definitely solved. Skinner, Savage, and Rutzler (*10*), and Deryagin (*11*) have proposed that adhesion and cohesion can be partly explained in terms of electrostatic phenomena. Skinner, *et al.*, show that in the case of a joint between a metal and a dielectric adhesive the double electric layer set up as a result of the difference in the Fermi levels is sufficient to account for a force of adhesion of 6 out of a total of about 1000 p.s.i. Under the right conditions the electrostatic effect could be as large as the other mechanisms causing adhesion. Some contribution from this effect is also made to the force of cohesion when failure occurs in the adhesive since the presence of the metal alters the electron distribution within the dielectric. Deryagin (*11*), in a qualitative theoretical treatment states that a similar effect may be found for the adhesion of two dielectrics or even when fracture occurs within a single dielectric. The force of attraction between two parallel surfaces having a surface charge σ e.s.u. per sq. cm. is equal to $2 \cdot \pi \cdot \sigma^2$ dynes per sq. cm. The work of adhesion A is then:

$$A = 2 \cdot \pi \cdot \sigma^2 \cdot h_d \qquad (3)$$
$$= \sigma \cdot V/2 \text{ ergs per sq. cm.}$$

where

h_d = the separation at which discharge occurs and, cm.
V = the discharge potential, v.

Since V depends on the pressure of the surrounding gas, there should be, according to this theory, a dependence of the work of adhesion on the gas pressure. Deryagin reports that such a relationship has been observed experimentally. The energy of the fastest secondary

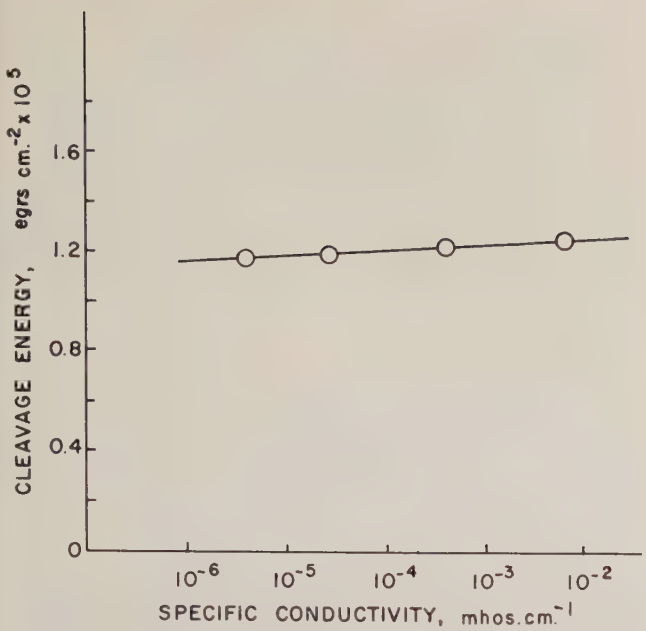

Fig. 8. Cleavage energy against conductivity of bath

electrons released by the discharge was found, in a separate experiment, to be as high as 10 kv. To justify values of A of 10^5 ergs per sq. cm., σ must then be about 6×10^4 e.s.u. per sq. cm. In reference (*11*) no evidence is provided to support the assumption of a charge of this magnitude, which if actually measured would explain the observed values of work of adhesion with an h_d of only 10^3 A.

A simple experiment was done to see whether any electrostatic effects were present to contribute to the cleavage energy measured in the present work. The results are shown in Fig. 8, which plots the effect of performing peeling experiments with the specimen submerged in water whose electrical conductivity was progressively increased by the addition of KCl. At the higher conductivity the charges, if any, should leak away and the separation energy should decrease. In practice, there appeared to be no dependence on the conductivity. The only, almost imperceptible, increase occurred in a sense opposite to that which would be brought about on the above theory.

The electrostatic effect must be absent in the fracture of metals, and yet here too there is a discrepancy of three orders of magnitude between the surface tension and the fracture surface energy. The mechanism through which the energy is dissipated is (*12*) mainly due to plastic deformation of a region close to the zone of failure. This reveals itself when the two halves of a metal object broken in apparent brittle failure are brought together. It is then found that the cracked surfaces cannot be made to fit perfectly. This must happen whenever a solid surface is irreversibly produced by mechanical means. If no deformation whatever accompanied the fracture it would be possible to fit the surfaces together again and obtain a perfect weld, together with the liberation of the surface free energy. This has apparently been achieved in an experiment performed by Bailey and Courtney-Pratt and described by Bowden (*13*) in which mica strips were split along a crystal plane. The cleavage energy was only 300 ergs per sq. cm. When the surfaces were brought together again, they adhered and almost

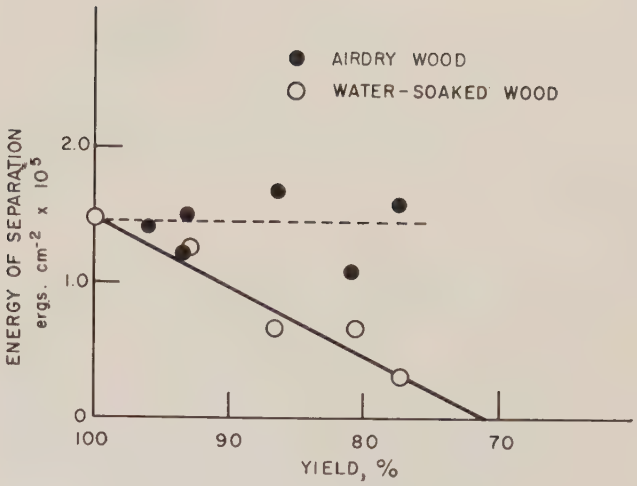

Fig. 9. Cleavage energy against yield

the same energy per square centimeter was required to repeat the separation. It seems reasonable to assume that the much greater cleavage energies observed with polymers are due to their random molecular structure, large molecular weights, and frequently weak cross-linking, which together can give rise to rearrangement of the molecular structure close to the plane of cleavage. The energy absorbed in this kind of deformation is eventually converted into heat, but being intrinsically associated with surface formation, cannot be regarded as a loss of the kind which contributes to the inefficiency of a pulping process.

A fibril being peeled from a fiber might be expected to behave like mica; since the macromolecules, being parallel, could be regarded as lying in crystal planes, and peeling as in the Van den Akker model would occur along these planes. A fiber wall peeled from its contiguous wall might show this kind of behaviour too, provided that no fibrils belonged to both walls. In the present experiments, failure for water-soaked wood always seemed to occur at the boundary between the compound middle lamella and the secondary wall. Since, in spite of this, the cleavage energy was of the order observed for polymers, one is led to the conclusion that the Van den Akker model cannot be applied to the peeling of fibers, and that another mechanism, probably also applicable to the fracture of homogeneous solids, must be valid.

The factor which is not considered in this model is the material consisting of lignin and hemicelluloses in which the microfibrils are embedded. The presence of this material alters the complexion of the process. The peeling of fibers or fibrils then becomes analogous to the peeling of adhesive-backed tape, for which peeling energies in the order of 10^5 ergs per sq. cm. have been observed (*14*), but for which no definitive theory appears to have been derived.

In Fig. 9 are shown the effects of delignification on the cleavage energy. Alcohol and ether-extracted wafers were delignified to various extents by treatment for various lengths of time in a sodium chlorite solution of pH 4.5 at 60°C. The abscissa in Fig. 9 is the yield or percentage of the original wood left after delignification. The original lignin content was 29% so that total delignification was equivalent to a yield of 71%. The tests were made with the wafers water-soaked and airdry and the results show the sensitivity of the

cleavage energy to treatment or removal of the embedding medium. This is hardly surprising, since it is, after all, the basis of chemical pulping.

It is interesting to note that while the cleavage energy drops almost linearly with the lignin content in the presence of water, it remains unaffected if the wood is permitted to dry.

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New Technique for Surface Sizing with Polyvinyl Alcohol

B. A. BEARDWOOD and E. P. CZERWIN

Widespread application of polyvinyl alcohol as a surface size for paper and paperboard has been limited in the past because solutions of polyvinyl alcohol penetrate too deeply into paper and paperboard. A new surface sizing technique has been developed which uses a pretreatment of borax solution to gel Elvanol* polyvinyl alcohol sizes on the surface of the sheet, thus preventing excessive penetration of the size. The two-stage borax-polyvinyl alcohol sizing technique has been evaluated on several types of paper and paperboard in laboratory studies and in mill trials. On all substrates the borax-polyvinyl alcohol size demonstrated excellent resistance to mineral oil penetration and improved resistance to turpentine penetration. In the laboratory, the borax-polyvinyl alcohol size was compared on an equal-cost basis to other sizes including straight polyvinyl alcohol, starch, sodium carboxymethylcellulose, and sodium alginate. Unbleached kraft linerboard was used as the substrate. The sized linerboard was tested for oil absorption, IGT printability, water absorption, and bursting strength. The borax-polyvinyl alcohol size gave superior oil holdout and was comparable to the other sizes in the other properties tested.

In the manufacture of a great deal of paper and paperboard, the surface size at the calender stack is the final treatment applied before printing and fabrication into consumer products. The surface size is applied for one reason—to improve the surface properties of the sheet. One important property which the surface size improves is the resistance of the paper fibers to penetration by water, oils, inks, and other liquids (*1*). In addition, the surface size binds loose fibers, gives the sheet greater resistance to picking during printing, and aids in the control of sheet texture and curl. It has been generally recognized that a surface size is only effective to the extent that it remains on the surface of the sheet. No advantages result when the size penetrates below the surface, except perhaps for some minor increase in internal strength (*2*).

* Elvanol is Du Pont's registered trademark for its polyvinyl alcohol.

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Elvanol polyvinyl alcohol, a water-soluble polymer, has been used for the surface sizing of paper and paperboard. Properties which makes its use as a surface size attractive include high adhesive strength and binding power, and excellent film-forming characteristics. Films of Elvanol polyvinyl alcohol are clear, tough, and flexible; they demonstrate outstanding resistance to printing inks and solvents. Recent research has shown, however, that solutions of polyvinyl alcohol often penetrate rather than remain on the surface of the paper sheet. Consequently, excessive and uneconomical amounts of polyvinyl alcohol are sometimes required to produce satisfactory sizing results.

The original aim of this work was to study those factors which affect penetration of polyvinyl alcohol solution into paper and paperboard. A further objective was to develop a method for retaining more of the polyvinyl alcohol on the sheet surface by preventing excessive penetration of the size solutions.

A two-stage sizing technique which takes advantage of a chemical reaction between borax and polyvinyl alcohol has been developed. The paper is pretreated with a borax solution and then sized with polyvinyl alcohol; the chemical reaction takes place on the paper surface, preventing penetration of the size into the sheet.

LABORATORY STUDIES

Size Penetration

Candidate sizing formulations based on polyvinyl alcohol were tested with the Vanceometer absorption tester (Fig. 1) for relative penetration into paper and paperboard. In this phase of the work, the procedure below was followed except that polyvinyl alcohol solutions were used instead of the mineral oil. A dense art board was chosen as the standard substrate for these tests in order that the penetration rate of all the polyvinyl alcohol solutions would be slow enough to be studied.

Vanceometer Oil Absorption Tester

"The Vanceometer Absorption Tester consists of a projection lamp and condenser lenses, mounted in such a way as to cast a beam of light on a sheet surface at an angle of 20°. The light is then reflected in a straight beam through an iris diaphragm, into a photoelectric cell connected to a microammeter. A thin film of oil is then cast onto the surface of the sheet and placed in the path of the beam of light, so that the light from the projector is reflected off the oil film into the photoelectric cell. By this means, it is possible to determine the gloss and continuity of the oil surface. As the oil film gradually disappears below the surface of the sheet, the light reflected into the photocell is lowered in direct proportion to the loss of oil into the sheet surface" (*3*).

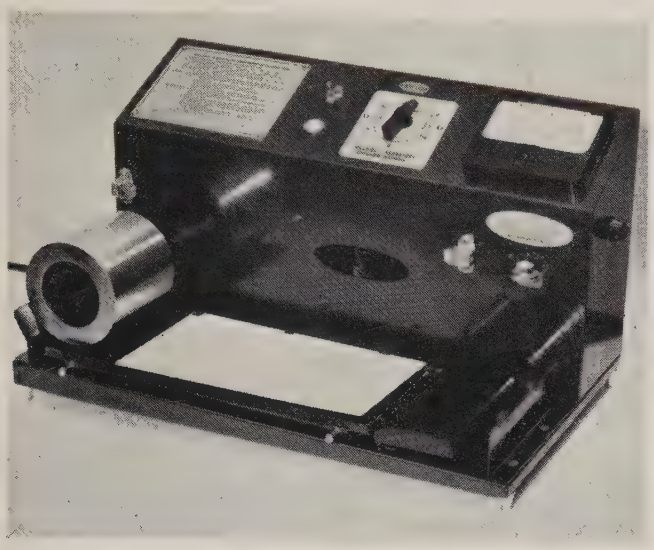


Fig. 1. Vanceometer oil absorption tester

By plotting the microampere readings against time, it was possible to compare the relative penetration rates for different polyvinyl alcohol sizes. This technique, based on the Vanceometer absorption tester, proved to be a quick, simple, and reproducible method for measuring size penetration rates. In later work, the Vanceometer was used to measure oil penetration into sized sheets as an evaluation test for gloss printing properties. Oil holdout also provided a real measure of the success in preventing deep penetration of polyvinyl alcohol-based sizes.

Effect of Solution Properties on Polyvinyl Alcohol Penetration

The first series of experiments studied the effect of size viscosity, solids concentration, and surface tension on the penetration of polyvinyl alcohol sizes. Three grades of fully hydrolyzed polyvinyl alcohol were used: an experimental grade of high viscosity polyvinyl alcohol, Elvanol 72-60 polyvinyl alcohol, and Elvanol 70-05 polyvinyl alcohol (Table I). The polyvinyl alcohol solutions were prepared by slurrying the dry polymer in cold water for 10 min., then cooking at 190 to 195°F. for 30 min. Water lost by evaporation was replaced.

Viscosity. Solutions of Elvanol 70-05, 72-60, and the experimental high viscosity polyvinyl alcohol were prepared at a concentration of 5.5% solids. At 25°C. the solutions had viscosities of 7, 220, and 440 cp., respectively. Portions of these solutions were mixed to give additional size solutions with viscosities of 88, 119, and 140 cp. at 5.5% solids. Polyvinyl alcohol

Table I. Grades of Polyvinyl Alcohol

Fully hydrolyzed polyvinyl alcohol	*Viscosity at 4% solids, cp.*	*Cost, ¢/lb.*
Experimental high viscosity grade	150	..
Elvanol 72-60	60	58
Elvanol 71-30	30	65
Elvanol 70-05	5	68

solutions with viscosities greater than 440 cp. were not investigated because it was felt that such viscous solutions would be impractical in commercial size press or calender stack application.

These six polyvinyl alcohol solutions were tested for penetration on the Vanceometer, as described above. The results, presented in Fig. 2, show that an increase in solution viscosity up to 220 cp. noticeably reduced the rate of size penetration and the ultimate penetration. Increasing the viscosity from 220 to 440 cp., however, gave only a slight improvement in holdout.

Solids Concentration. Solutions of Elvanol 70-05, 72-60, and the experimental high viscosity polyvinyl alcohol were prepared at a viscosity of 220 cp.; these solutions had solids concentrations of 14.5, 5.5, and 4.5%, respectively. The three solutions were then tested for size penetration. The Vanceometer data, plotted in Fig. 3, show that an increase in solids resulted in a considerable improvement in size holdout. Comparing Figs. 3 and 2, the highly concentrated solutions demonstrated less penetration than the highly viscous solutions. Use of the necessary high solids would probably be too expensive and would certainly accentuate sticking on the calender stacks.

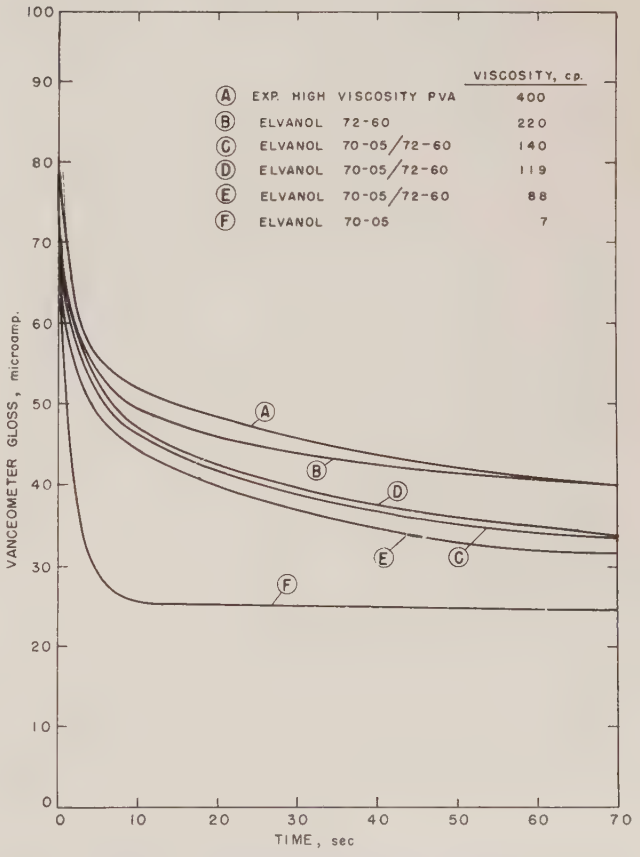


Fig. 2. Effect of solution viscosity on size penetration; size solutions applied at 5.5% solids

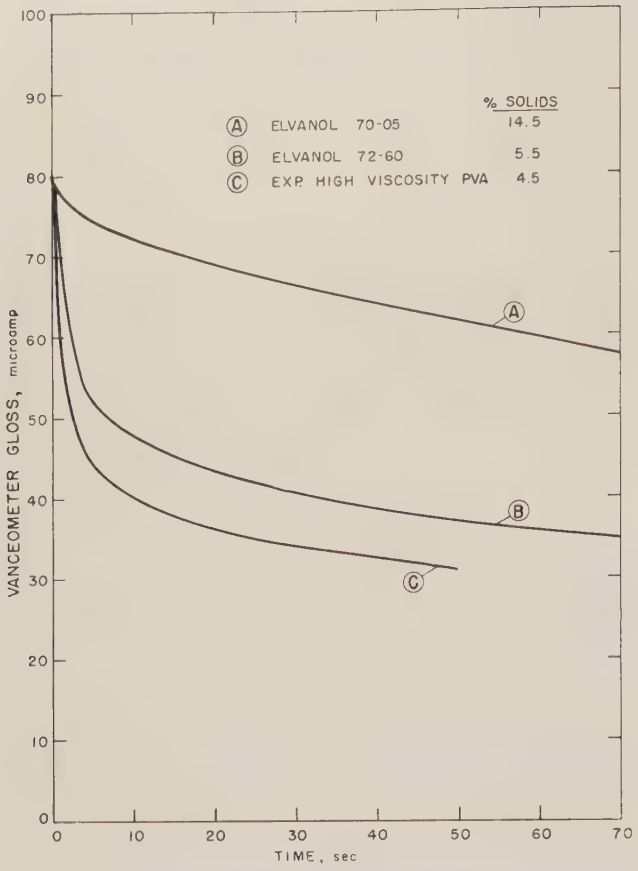


Fig. 3. Effect of solution solids on size penetration; viscosity of size solutions = 220 cp.

Surface Tension. The surface tension of a 5.5% solution of Elvanol 72-60 was reduced from 72 to 35 dynes per cm. by the addition of a surfactant* (0.2% based on solution). The effect of surface tension on polyvinyl alcohol size penetration was investigated using these two solutions. The results determined with the Vanceometer are presented in Fig. 4. Lowering of the surface tension did not change the ultimate penetration of the polyvinyl alcohol size, but it did slightly decrease the initial rate of penetration.

* Triton X-100, alkyl aryl polyether alcohol (Rohm and Haas Co., Philadelphia, Pa.).

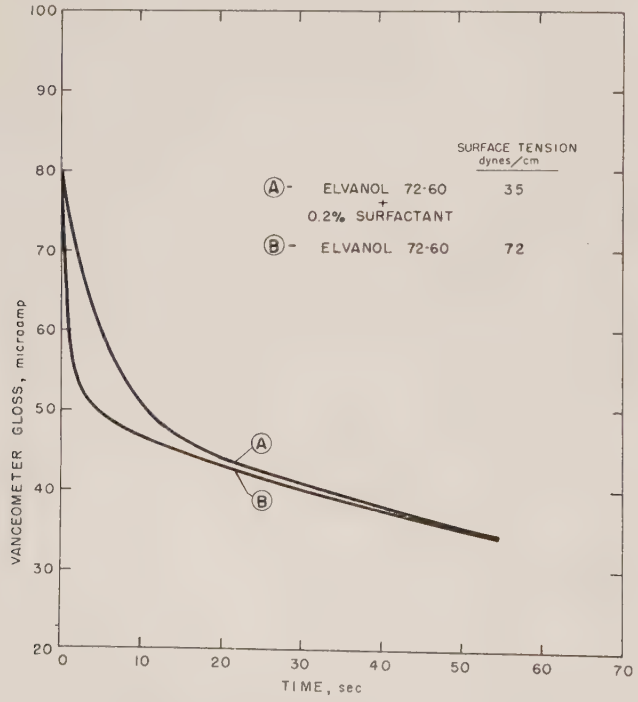
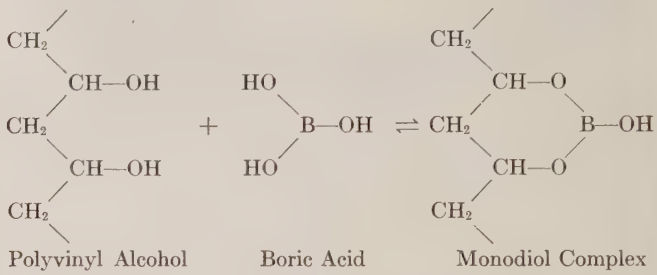


Fig. 4. Effect of surface tension on size penetration; size solutions at 5.5% solids and 220 cp.

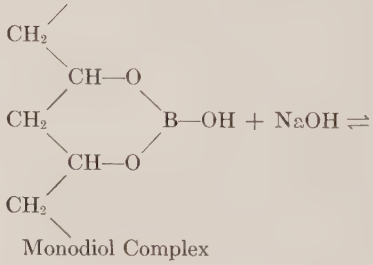
Gelling Agents for Polyvinyl Alcohol

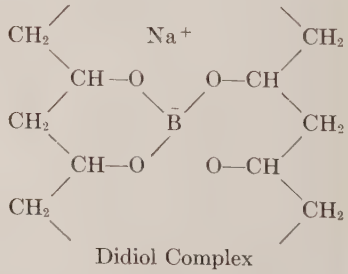
Since varying the viscosity, solids concentration, or surface tension did not appear promising as practical techniques to control the penetration of polyvinyl alcohol sizes, an evaluation of a number of gelling agents for polyvinyl alcohol was made. These gelation and precipitation agents were tested as pretreatments designed to gel the polyvinyl alcohol on the surface of the sheet, preventing excessive size penetration.

Borax as a Gelling Agent. The reaction between aqueous tetrasodium borate decahydrate (borax) and polyvinyl alcohol is well known (*4, 5*). Mechanisms describing the reaction of boric acid and borax with polyvinyl alcohol have been presented in the literature (*6*). In an aqueous system, boric acid and polyvinyl alcohol combine to form a polyvinyl alcohol/boric acid monodiol:



This reaction results in a slight viscosity increase but does not precipitate or gel the polyvinyl alcohol at boric acid levels of 20% or less, based on the polyvinyl alcohol. The addition of an alkaline material to the polyvinyl alcohol/boric acid monodiol solution, or a direct combination of polyvinyl alcohol and borax results in the formation of the didiol complex of polyvinyl alcohol and boric acid:





The formation of the didiol complex leads to the development of a stable three-dimensional gel network. The didiol complex reaction is reversed to the monodiol complex by the addition of excess acid. Sorbitol,

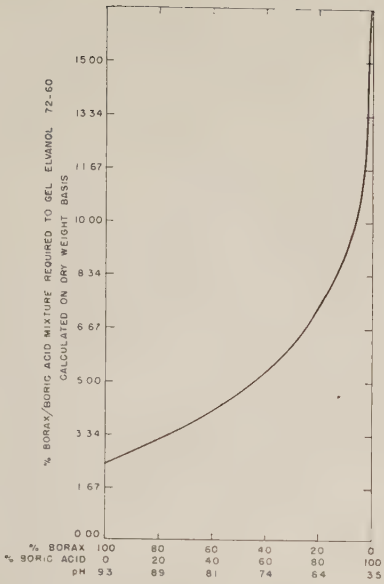


Fig. 5. Effect of ratio of borax/boric acid at 5% total solids on quantity of mixture required to gel 3% solution of Elvanol 72-60

hydrogen peroxide, and weak acids are effective agents for both breaking the didiol gel structure and preventing its formation.

Borax/Boric Acid Mixtures. In an effort to define the effect of borax and boric acid, and combinations of both, on polyvinyl alcohol solutions, a study was made to relate the pH of borax/boric acid solutions to the amount of borax/boric acid required to gel a polyvinyl alcohol solution. A number of borax/boric acid solutions were made at a total concentration of 5% solids. The pH of these solutions decreased from 9.3 to 3.5 as the ratio of borax to boric acid was changed from 1:0 to 0:1.

A solution of Elvanol 72-60 polyvinyl alcohol at 3% solids was gelled with the different borax/boric acid solutions. As the ratio of borax to boric acid was decreased, more of the gelling solution was required to gel the same amount of Elvanol 72-60 solution. A relationship was established between the ratio of borax to boric acid (or the pH of a borax/boric acid mixture) and the amount of borax/boric acid required to gel a constant amount of polyvinyl alcohol. This relationship is presented graphically in Fig. 5.

Solutions of polyvinyl alcohol and boric acid will gel with the addition of enough base to convert some boric acid to borax. Gels of borax and polyvinyl alcohol, on the other hand, can be liquefied by the addition of enough acid to convert the borax to boric acid.

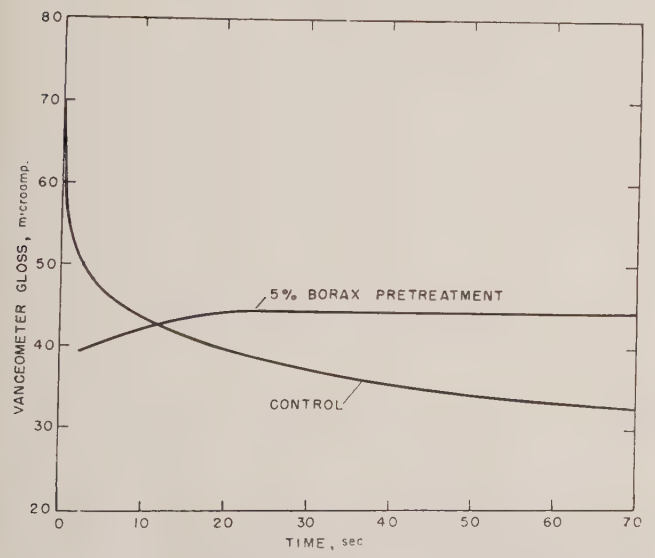


Fig. 6. Effect of borax pretreatment on size penetration of a 5.5% solution of Elvanol 72-60

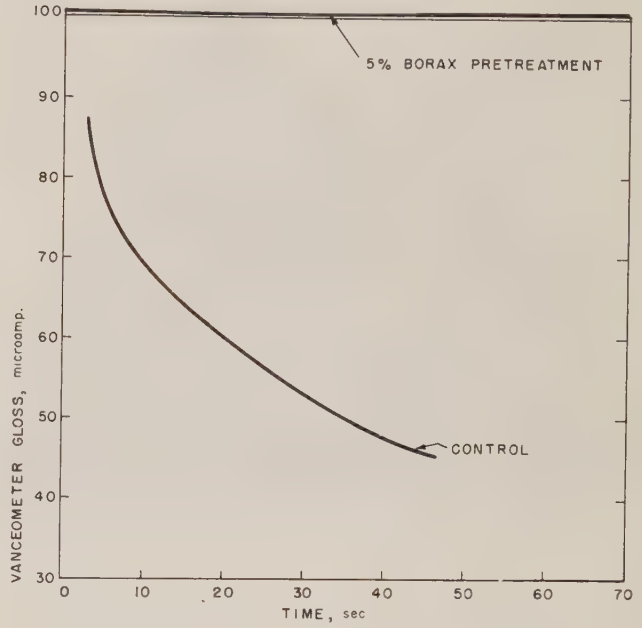


Fig. 7. Effect of borax pretreatment on oil absorption of board sized with 5.5% solution of Elvanol 72-60

Effect of Borax on PVA Holdout. Of all the materials tested, borax proved to be the most effective pretreating agent for preventing deep penetration of polyvinyl alcohol sizes. The effect of borax as a pretreatment for the prevention of polyvinyl alcohol penetration into paper and paperboard was illustrated with the following experiment: A sample of the dense art board was treated with a 5% solution of borax and allowed to air-dry. A 5.5% solution of Elvanol 72-60 was then tested for penetration on both the borax-pretreated and the untreated board. The Vanceometer data from these tests are plotted in Fig. 6. The Vanceometer curve representing the Elvanol 72-60 penetration into the borax-pretreated art board is flat, indicating a zero rate of size penetration. The polyvinyl alcohol solution penetrated into the untreated art board as it did in the previous tests.

Effect of Borax-PVA Treatment on Oil Holdout. The art board, sized in one case with only Elvanol 72-60 and in the other with borax and Elvanol 72-60, was tested for oil absorption using the standard viscosity oil NCS-12,* according to the Vanceometer procedure previously described. The Vanceometer oil absorption data, plotted in Fig. 7, showed that the two-stage borax-polyvinyl alcohol size was effective in providing complete oil holdout for 60 sec.; the same polyvinyl alcohol size applied with no borax pretreatment allowed oil penetration. In this and later work the Vance-

* Standard viscosity mineral oil (Hillside Laboratory, Chicago, Ill.).

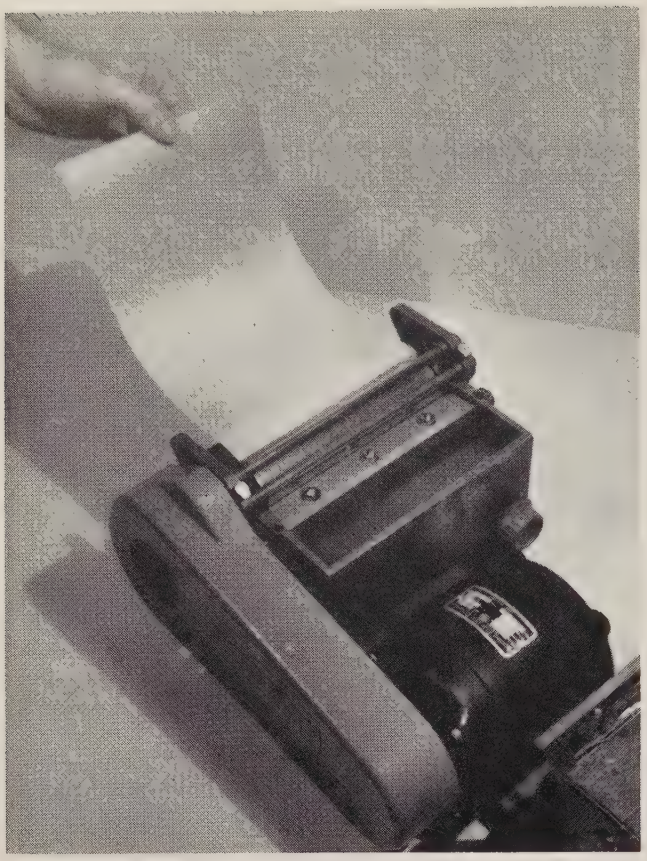


Fig. 8. Potdevin label paster

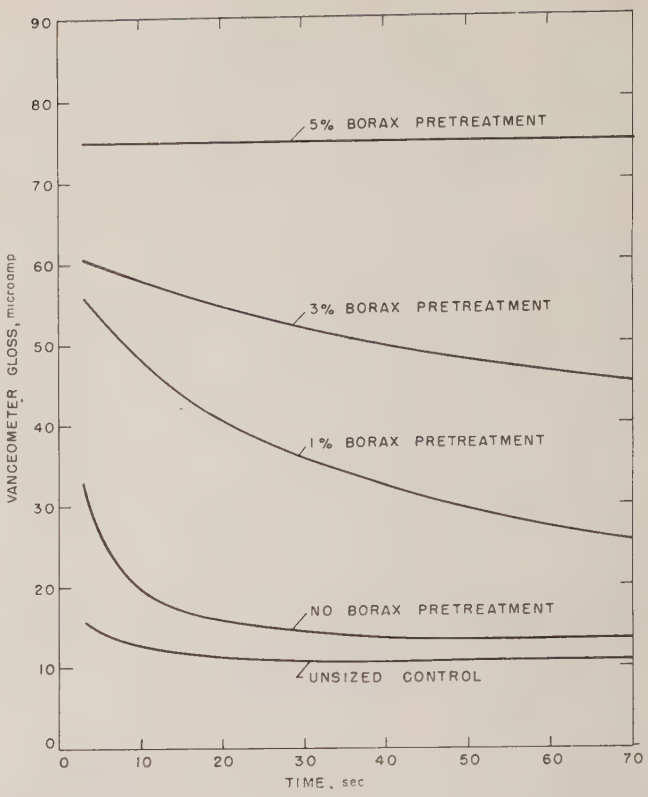


Fig. 10. Effect of borax concentration on oil absorption of kraft liner sized with 3% Elvanol 72-60 solution

ometer oil absorption data were used as a measure of the original polyvinyl alcohol size holdout.

Effect of Ratio of Borax to PVA on Oil Holdout. Although paper and paperboard sized for solvent holdout or grease resistance should demonstrate the highest possible degree of oil holdout, high gloss printing does not require absolute oil holdout. In fact, too much resistance to penetration by printing inks may cause offset in some printing operations.

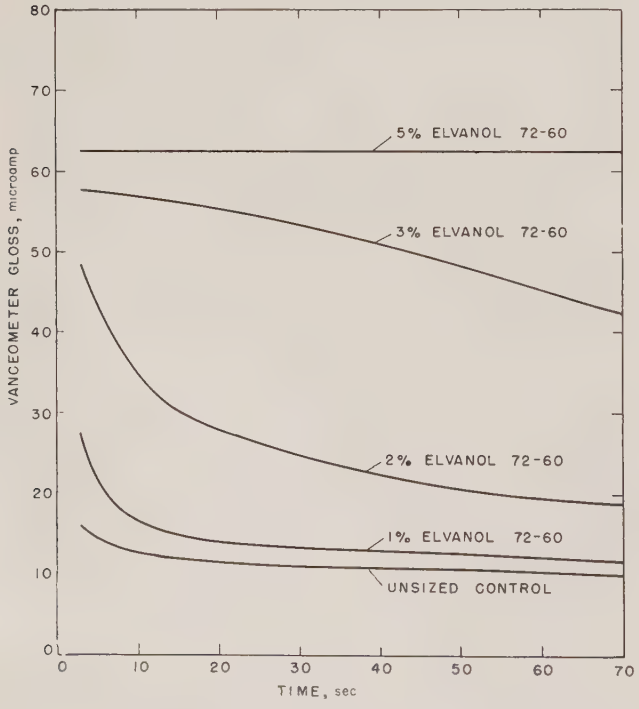


Fig. 9. Effect of polyvinyl alcohol concentration on oil absorption of kraft liner pretreated with 3% borax solution

Kraft linerboard was used to study the effect of the ratio of borax to polyvinyl alcohol on the oil resistance of the sized sheet. In the first series of experiments, the kraft linerboard was pretreated with a 3% solution of borax, then sized with Elvanol 72-60 solutions at concentrations of 5, 3, 2, and 1% solids on the Potdevin label paster (Fig. 8). This allowed the application of a range of Elvanol sizing weights. After conditioning, the sized sheets were tested for oil absorption on the Vanceometer. The data, plotted in Fig. 9, showed that oil holdout increased as the concentration of polyvinyl alcohol increased.

The same kraft linerboard, in the second series of experiments, was pretreated with equal pickups of borax solutions at concentrations of 5, 3, and 1% solids. The pretreated sheets were all sized with 3% solutions of Elvanol 72-60 at equal size add-on. After conditioning, these sheets were also tested for oil absorption. The Vanceometer data (Fig. 10) clearly showed that the oil holdout increased uniformly as the quantity of borax pickup was increased. These data also indicate that the polyvinyl alcohol size holdout increased as the quantity of borax pickup increased.

These experiments illustrated that varying degrees of oil holdout can be achieved by controlling the ratio of borax to polyvinyl alcohol. In a commercial operation it will be necessary to establish the optimum ratio of borax to polyvinyl alcohol for the desired degree of sizing. Usually it appears preferable to start with the borax solution at 5% solids and vary the polyvinyl alcohol solids to obtain the required oil holdout.

Table II. Summary of Laboratory Sizing Tests

Substrate	*Kraft linerboard, 10 pt., lb./1000 sq. ft. 33*			*Kraft board, 22 pt. 90.7*		*Kraft wrapper 5 pt. 20.8*		*Bleached fourdrinier food board, 12 pt. 54.3*		*Patent coated board, 122*		*Chip board, 20 pt. 69.3*		
	Size Cost (¢/1000 sq. ft.)													
Elvanol 72-60	...	5.6	7.5	...	5.7	...	7.0	...	3.3	5.7	...	4.0	...	4.5	7.7
Borax	...	1.5	1.5	...	1.5	...	1.5	...	1.5	1.5	...	1.5	...	1.5	1.5
Total cost	0.0	7.1	9.0	0.0	7.2	0.0	8.5	0.0	4.8	7.2	0.0	5.5	0.0	6.0	9.2
	Test Results														
IGT Printability—speed of picking, f.p.m., no. 8 ink	180	>650	>650	>650	>650	500	650	650	650	650	120	650	0–100	250	350
Mullen burst, p.s.i.	75	85	109	>120	>120	44	52	83	93	97	>120	>120	69	78	76
Cobb size, g.	0.45	0.44	0.45	0.57	0.33	0.53	0.35	0.41	0.33	0.36	0.21	0.22	1.55	0.76	0.75
Vanceometer oil absorption, gloss, microamp.															
5 sec.	14	58	62	24	90	18	100+	47	92	98	67	90	10	87	89
20 sec.	12	58	64	18	91	14	100+	30	93	99	41	90	10	83	90
60 sec.	12	58	64	17	91	12	100+	26	93	100	27	90	10	68	89

Surface Sizing by the Two-Stage Borax-Polyvinyl Alcohol Treatment

Laboratory Sizing Methods. Paper and paperboard were pretreated by brushing an aqueous solution of borax onto the sheet surface. The pretreated sheets were allowed to air-dry before sizing. They were then sized on the 6-in. Potdevin label paster. Approximately 250 ml. of the polyvinyl alcohol size solution was placed in the paster reservoir. Samples (6 by 10 in.) were sized by making a single pass through the paster operating at a line speed of 45 f.p.m. Pickup weights were determined by weighing the paper samples immediately after sizing. Adjustments in dry sizing weights were made by changing the concentration of the size solution. The sized samples were allowed to air-dry and were not calendered. The sheets were conditioned for a minimum of 24 hr. at 73°F. and 50% R.H. (TAPPI Standard T 403 m-58).

Test Results. The borax-polyvinyl alcohol treatment was applied to six different substrates including unbleached kraft board, linerboard, and wrapper; bleached kraft fourdrinier board; patent coated newsboard; and chip board. The pretreatment was made with a 5% borax solution. Pretreatment weights were maintained at 0.5 lb. of borax per 1000 sq. ft., representing a raw materials cost (RMC) of about 1.5¢ per 1000 sq. ft. (approximately $0.30 per ton of board). A size of Elvanol 72-60 was applied to the pretreated sheets on the Potdevin label paster. Dry pickup weights were in the range of 0.057 to 0.133 lb. of polyvinyl alcohol per 1000 sq. ft., representing a RMC of 3.3 to 7.7¢ per 1000 sq. ft. (approximately $0.66 to $1.60 per ton of board).

After conditioning, the following evaluation tests were made:

1. Vanceometer oil absorption test.
2. Cobb size test (TAPPI Standard T 441 m-45).
3. Mullen burst strength (TAPPI Standard T 403 m-58).
4. IGT printability test (7).

The test results on the six substrates are described below and summarized in Table II.

Vanceometer oil absorption. In these tests the Vanceometer gloss was reported after 5, 20, and 60 sec. By comparing the gloss at these intervals, it was easy to determine if the oil penetrated into the sheet. Although the Vanceometer data on most of the boards were constant at the different times, indicating no oil penetration, the values were not exceptionally high in some instances. This is probably due to the fact that the sheets were not calendered after sizing. The very porous chip board, sized at a total RMC of 6.0¢ per 1000 sq. ft., showed some oil penetration. In contrast, all the other samples demonstrated no drop in Vanceometer gloss during the first 60 sec. The chip board did show excellent oil holdout at a higher sizing level, RMC of 9.2¢ per 1000 sq. ft.

Cobb size test. Generally, the borax-polyvinyl alcohol treatment did not cause any change in the water sensitivity of those sheets which had Cobb values below 0.5 g. before sizing. This was true in the case of the kraft linerboard and the patent coated news board. The borax-polyvinyl alcohol treatment reduced the water sensitivity of the other sheets which had original Cobb values greater than 0.5 g.

Under certain conditions, borax, like most alkaline materials, may react with and reduce the effectiveness of the alum/rosin internal size. The degree of interreaction depends upon the strength of the alkaline material, temperature, and time allowed for the reaction to continue. Under the conditions of mill operation, where the borax solution is dried rapidly, no evidence of internal size degradation has been noted. In some laboratory experiments, when borax-pretreated sheets were dried at room temperature, there was a reduction in water resistance, as measured by the Cobb size test.

Control of the Cobb values of high gloss printing sizes is particularly important in high-speed gluing operations with water-based adhesives. Other work has shown that a range of Cobb values can be achieved with the borax-polyvinyl alcohol size by using different viscosity grades of polyvinyl alcohol. The higher viscosity grades are more water resistant than are the lower viscosity grades. Also, the addition of small amounts of certain wetting agents such as Alkanol* crude solution to the size formulation was effective in increasing the Cobb value of the sized sheets.

Mullen burst strength. The borax-polyvinyl alcohol treatment increased the burst strength of the test sheets. The increases ranged from 12% for bleached kraft fourdrinier board to 45% for the kraft linerboard.

7IGT printability test. The IGT pick tests were made

* Du Pont's registered trademark for its surface active agent—alkylnaphthalene sodium sulfonate.

Table III. Sizes for Paper and Paperboard

Materials	*Type*	*Cost, ¢/lb.*
Elvanol 72-60 polyvinyl alcohol	Fully hydrolyzed, high viscosity	58
Tetrasodium borate	Decahydrate	2.5
Sodium carboxymethyl-cellulose	Low viscosity	60
Sodium alginate	Low viscosity	90
Starch	Acid-modified	9
3:1 Starch/polyvinyl alcohol	...	22

according to the usual procedure (*7*) using no. 8 standard tack ink. This ink has the highest tack of those used with the IGT tester. The results were reported as the speed, in feet per minute, at which fiber picking began. In this work it was found that the unsized kraft fourdrinier board and kraft board showed no fiber tear up to speeds of 650 f.p.m., the upper limit of the IGT tester. The other unsized sheets, however, all picked at speeds lower than 650 f.p.m. The borax-polyvinyl alcohol sizing technique successfully eliminated ink picking at speeds up to 650 f.p.m. on all the samples except the chip board. The unsized chip board showed essentially no pick resistance. With the borax-polyvinyl alcohol size, the pick resistance of this board was increased to 250 and 350 f.p.m. at RMC levels of 6.0 and 9.2¢ per 1000 sq. ft., respectively.

Comparative Evaluation of Different Sizing Agents

Before the development of the borax-polyvinyl alcohol sizing technique, a great deal of work was done comparing the sizing performance of Elvanol 72-60 polyvinyl alcohol with sodium carboxymethylcellulose, sodium alginate, and an acid-modified starch (Table III) (*8*). These sizing materials, and also a 3:1 mixture of starch: Elvanol 72–60, were applied to kraft linerboard, bleached foodboard, and patent coated board. Application rates were controlled so that the RMC of the size was maintained at 7.5¢ per 1000 sq. ft. The sheets were calendered and conditioned before testing.

The identical kraft linerboard used in the comparative sizing study was treated in this work with the borax-polyvinyl alcohol size. The borax pretreatment and the polyvinyl alcohol size were applied at rates equivalent to 1.5 and 6.0¢ per 1000 sq. ft., respectively, making a total sizing cost of 7.5¢ per 1000 sq. ft. These sheets were conditioned but not calendered before testing (TAPPI Standard T 403 m-58).

Test Results. To determine the effectiveness of the borax-polyvinyl alcohol treatment as compared with other sizes, the sized sheets were evaluated with the following tests: Vanceometer oil absorption test, the Cobb size test, the Mullen burst strength, and the IGT printability test.

Vanceometer oil absorption. All sized sheets were tested for oil holdout on the Vanceometer absorption tester. The Vanceometer data are plotted in Fig. 11. The polyvinyl alcohol showed better holdout than either the sodium alginate or the CMC. Although the starch performed better than the polyvinyl alcohol and the starch/polyvinyl alcohol mixture, the two-stage borax-polyvinyl alcohol size had the best oil resistance. The initial Vanceometer readings for some of the sizes were higher than for the borax-polyvinyl alcohol size. This was probably due to the fact that the borax-

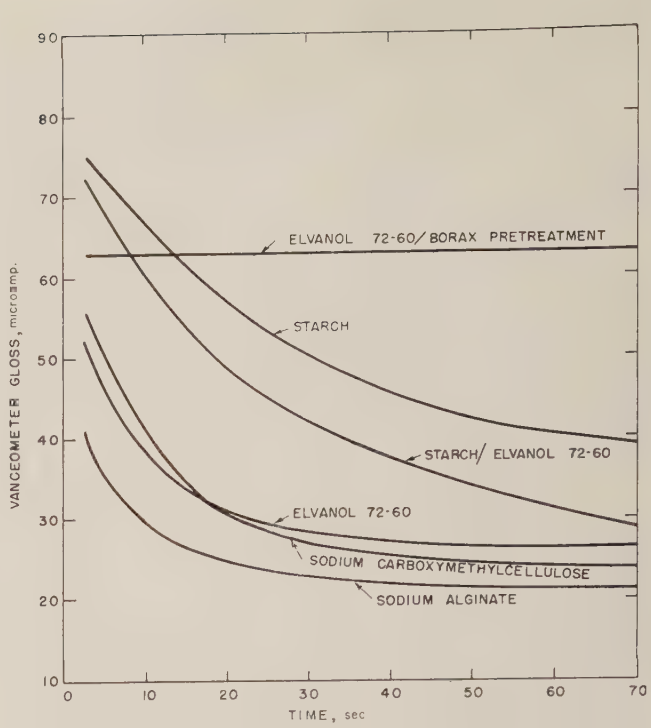


Fig. 11. Comparison of effect of sizing agents on oil absorption of kraft liner at size add-on equivalent to 7.5¢/1000 sq. ft.

polyvinyl alcohol sized sheets were the only ones not calendered.

Cobb size test. The starch/polyvinyl alcohol and the borax-polyvinyl alcohol sizes showed very little change in water absorption values from the unsized control, as shown in Fig. 12. As was previously mentioned, it is possible to increase the Cobb values of

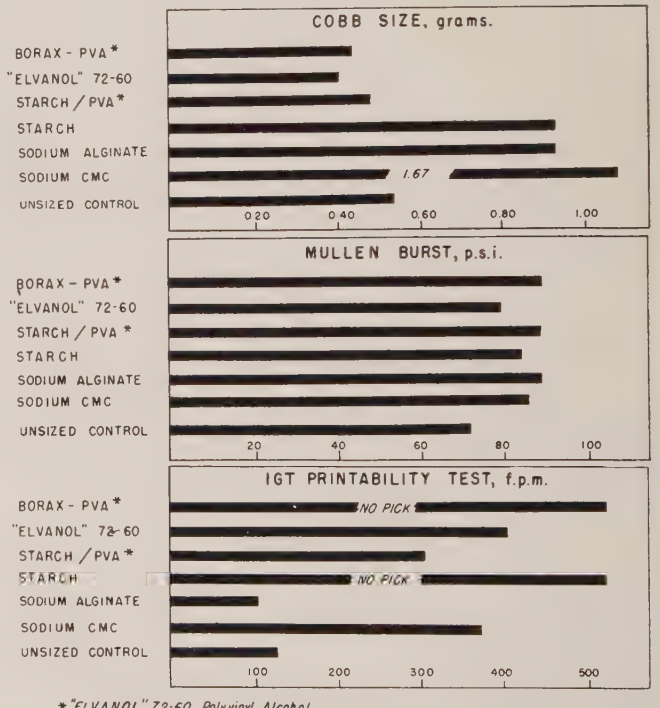


FIG. 12

COBB SIZE, MULLEN BURST & IGT PRINTABILITY OF KRAFT LINER TREATED WITH VARIOUS SIZING AGENTS, APPLIED AT 7.5¢/1000 SQ.FT.

Fig. 12. Cobb size, Mullen burst and IGT printability of kraft liner treated with various sizing agents; applied at 7.5¢/1000 sq. ft.

Table IV. Summary of Test Results on Patent Coated News Board Sized in Mill Trials

Substrate	*Trial I*		*Patent coated newsboard* *Trial II*						*Trial III*			
Pretreatment solution	None	5% Borax	5% Borax	5% Borax		5% Borax	5% Borax		5% Borax	5% Borax		
Size solution	2.5% Elvanol 72-60	2.5% Elvanol 72-60	2% Elvanol 72-60	4% Elvanol 72-60		6% Elvanol 72-60			5% Elvanol 71-30	5% Elvanol 71-30 and 5% Texo-Film 6088 (mixture)		
Test Results												
Age, days	22	103	22	103	1	145	1	145	1	145	22	68	22	68
TAPPI turpentine test, sec.	...	17	...	68	15	21	60	30	150	460	61	113	145	315
Cobb size test, g.	3.53	3.20	2.96	1.90	..	0.69	...	0.70	...	0.62	0.29	0.40	0.32	0.36
Mullen burst, p.s.i.	89	117	91	118	..	101	...	99	...	108	110	111	111	114
Vanceometer oil absorption gloss, microamp.														
5 sec.	90	86	94	100+	94	90	100	98	100+	100+	87	91	94	96
20 sec.	84	78	93	100+	81	80	100	97	100+	100+	85	88	93	96
60 sec.	65	57	93	98	51	52	97	91	100+	100+	76	80	90	93

polyvinyl alcohol sizes by using low molecular weight grades of polyvinyl alcohol or by modifying the polyvinyl alcohol size with small amounts of a surfactant. The starch, CMC, and sodium alginate sizes all showed water-absorption values considerably higher than the unsized control.

Mullen burst strength. The starch/polyvinyl alcohol mixture resulted in the largest improvement in burst strength (Fig. 12). All the other sizes were approximately equivalent in performance, increasing the strength of the kraft linerboard about 18%.

IGT printability test. Kraft linerboard sized by the borax-polyvinyl alcohol technique and with starch resisted picking on the IGT up to speeds of 650 f.p.m. with the no. 8 standard tack ink (Fig. 12). The starch/polyvinyl alcohol, the polyvinyl alcohol, and the CMC sizes were approximately equivalent in pick resistance. All the sizes outperformed the sodium alginate which showed no improvement over the unsized control.

One-Stage Sizing

A number of modifiers were evaluated as additives to polyvinyl alcohol solutions in an attempt to develop a one-stage formulation which would show reduced penetration into the sheet. The only successful technique involved a mixture of boric acid and polyvinyl alcohol applied to paper or paperboard with an alkaline surface. Solutions of Elvanol 72-60 modified with up to 20% boric acid (based on polyvinyl alcohol solids) remain stable and fluid below pH 7.5. When boric acid/polyvinyl alcohol solutions are applied to alkaline board, the boric acid is converted to borate and the polyvinyl alcohol gels immediately on the surface of the sheet. Since most paper and paperboard is acidic, this one-stage sizing technique appears to have only limited application; therefore, the two-stage borax-polyvinyl alcohol system has been emphasized in this work.

MILL STUDIES

Based on the promising laboratory results, the two-stage borax-polyvinyl alcohol surface size was evaluated on a commercial scale in several mill trials. The borax-polyvinyl alcohol technique has now been in continuous use in one mill for a period of almost a year. The mill results discussed below were determined in three early mill trials. In these three different trials, the borax and polyvinyl alcohol were applied in the same manner. The borax solution, at 5% solids, was applied to the board from the top water box on the wet calender stack. Polyvinyl alcohol solutions were applied from a second water box on the same calender stack. Although gelation of polyvinyl alcohol in the second water box and sticking on calender stack were not encountered in these trials, dilute solutions of a gel-breaking agent (e.g., an acid, sorbitol, or hydrogen peroxide) were kept nearby in case the borax and polyvinyl alcohol solutions were inadvertently mixed.

If it is not convenient to apply both the borax pretreatment and polyvinyl alcohol size on the same calender stack, other application arrangements can be employed. The borax pretreatment has been applied from a spray head in the drying train. Borax solutions have also been applied at the size press. Based on mill experience, similar sizing results can be expected with the borax-polyvinyl alcohol treatment using either water box, size press, or spray technique for the borax pretreatment.

The results obtained with the borax-polyvinyl alcohol size in actual mill operation were similar to those attained in the laboratory. The borax pretreatment was extremely effective in reducing the penetration of the polyvinyl alcohol-base sizes into the sheet. The improved size holdout resulted in improved oil and grease resistance. Because these early sizing trials were of relatively short duration, it was not possible to determine firm cost data.

Samples of all the sheets sized in the trials were retained and conditioned according to TAPPI Standard T 403 m-58. The sheets were tested soon after the trial and then stored for extended periods of time at 73°F. and 50% R.H. before retesting. The evaluation tests included the Vanceometer oil absorption test, turpentine penetration test (TAPPI Standard T 454 m-44), Cobb size test, and the Mullen burst test. The results from the three trials are discussed below and summarized in Table IV.

Patent Coated Newsboard—Trial I

The top liner of patent coated newsboard was sized in this mill trial. Control samples were prepared by sizing with a 2.5% solution of Elvanol 72-60 on the calender stack. The two-stage borax-polyvinyl alcohol treatment was made with an application of 5% borax solution from the top water box on the calender stack,

followed with an application of 2.5% Elvanol 72-60 from a second water box on the same stack. Addition of the borax water box created no sizing difficulties but care was taken to prevent any of the borax solution from leaking into the box containing the polyvinyl alcohol solution.

The Vanceometer oil absorption data showed that the borax-polyvinyl alcohol technique resulted in greater oil resistance than did the size of only polyvinyl alcohol. The water absorption values were less for the board sized with the borax-polyvinyl alcohol system. The burst strength was approximately the same for both treatments. After the board had aged 103 days, the tests were repeated. The Vanceometer oil absorption results were essentially unchanged after aging. The Cobb values were lower, especially on the board sized with borax-polyvinyl alcohol. The burst strengths increased equally on the two samples. Grease resistance was measured on both the sheets according to the standard TAPPI turpentine test. The borax-polyvinyl alcohol size showed much more resistance to penetration by turpentine than the straight polyvinyl alcohol size.

Samples of board from both runs, aged 103 days, were checked for Hunter reflectance as a measure of whiteness. The readings were the same for both the borax-pretreated board and the untreated board, indicating that the borax had caused no color reversion nor darkening of the bleached top liner.

Patent Coated Newsboard—Trial II

At a second mill, another sizing trial was made using the top liner of patent coated newsboard. In this trial three runs were made, all employing a pretreatment of 5% borax solution at the top water box on the wet calender stack. Elvanol 72-60 polyvinyl alcohol solutions were applied from a second box on the same calender stack at solids concentrations of 2, 4, and 6%. No difficulties were encountered with the two-stage borax-polyvinyl alcohol sizing method.

After the sized board had conditioned for 24 hr., Vanceometer oil absorption and turpentine penetration tests were made. The oil holdout increased as the polyvinyl alcohol size add-on was increased in a manner similar to that demonstrated in the laboratory (Fig. 9). Likewise, the turpentine resistance of the sized sheets was improved with increased polyvinyl alcohol add-on. After the board had aged for 145 days under standard conditions, oil absorption was measured again and found to be essentially unchanged. Although the turpentine resistance on the aged board sized with 2 and 4% Elvanol 72-60 was practically unchanged, the grease resistance of the board sized with 6% Elvanol 72-60 increased more than twofold with aging.

Cobb size and Mullen burst strength tests were made on the aged samples. The sheets sized at the three polyvinyl alcohol levels were approximately equivalent in Cobb values. The 6% Elvanol 72-60 size had a slightly higher burst strength than the 2 and 4% sizes.

Patent Coated Newsboard—Trial III

The news side of patent coated newsboard was sized at a third mill. In this trial the use of a thin-boiling starch* was evaluated as an extender for the borax-polyvinyl alcohol size. Two runs were made, each employing a pretreatment of 5% borax solution. The pretreatment and size were both applied on the wet calender stack. In the first run, a solution of 5% Elvanol 71-30 polyvinyl alcohol (Table I) was applied to the borax-pretreated sheet. After a quantity of board had been sized under these conditions, a second run was made with a 50:50 mixture of Elvanol 71-30 and Texo-Film 6088 at 10% total solids concentration. Samples from each run were conditioned and tested. Oil absorption and turpentine penetration tests showed that the board sized with the starch/polyvinyl alcohol mixture had more grease resistance than the board sized with the polyvinyl alcohol. Cobb size and Mullen burst strength tests showed that the two boards were approximately equivalent in water resistance and burst strength.

After the samples had aged 68 days, they were tested again for oil absorption and turpentine penetration. The grease resistance of the board had increased with aging. The starch/polyvinyl alcohol size, however, still showed greater resistance than the polyvinyl alcohol. Water absorption and bursting strength of the sized samples remained unchanged after aging.

* Texo-Film 6088 (Corn Products Co., New York, N. Y.)

CONCLUSIONS

1. The viscosity, solids concentration, and surface tension of polyvinyl alcohol solutions have little practical effect on the penetration of polyvinyl alcohol sizes into paper and paperboard.
2. The use of a borax pretreatment to gel polyvinyl alcohol sizes on the sheet surface is an effective technique for preventing excessive size penetration.
3. The borax-polyvinyl alcohol treatment results in excellent oil holdout and improves turpentine resistance when applied to several different kinds of paper and paperboard.
4. When compared to several other sizing agents, on an equal cost basis, the borax-polyvinyl alcohol treatment gives superior resistance to oil and turpentine penetration.
5. Mill trials confirmed laboratory results of the borax-polyvinyl alcohol treatment on the oil- and turpentine-resistant properties of paper and paperboard.
6. For sizing paper and paperboard with an alkaline surface, polyvinyl alcohol solution modified with boric acid is effective as a single-stage size for improved oil and turpentine resistance.
7. The properties of paper and paperboard sized with the borax-polyvinyl alcohol treatment are essentially unchanged after aging.

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Operating Variables of a Blade Coater

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The amount of coating applied by a trailing blade coater is generally considered to be related to the base sheet, the coating color and the doctoring action of the blade. In carrying out a study of the doctoring action it was found that coating weight varied as a function of doctor blade pressure. A simple method for calculating blade pressure is described. For a system with fixed base stock, coating color, and operating speed, a quantitative statement for the coating weight-blade pressure relationship has been developed. The qualitative effects of variations in base stock, color, and speed are discussed.

PIGMENTED coatings are generally applied to paper for two reasons: to change or improve the appearance, and to improve the printability. Because of its ability to produce smooth, pattern-free coatings, the flexible blade coater is considered to be well suited for the task of preparing surfaces for printing.

The growth and use of the trailing blade occurred over a relatively short period of time. In the last decade the number has increased from just a few to something over 100 units at the present time. This in itself illustrates the capabilities of the blade coater. In spite of the tremendous popularity of the blade coater, relatively little has been published regarding its operation. The information available in the literature (*1–4*) on control of coating weights indicates only that it is effected by coating color solids, paper absorbency, and machine speed. While these broad statements are helpful in general discussions of blade coaters, they leave many questions unanswered concerning the actual operation of the unit. To utilize more fully the potential of the flexible blade in our affairs, we, at the Central Research Department at Crown Zellerbach, found it desirable to determine what variables actually did control coating weight.

EXPERIMENTAL

The first step in the study was the determination of the relationship between blade pressure and coating weight, since blade pressure must be the basic mechanism by which coating weight is controlled. Subsequently, the effects of changes in solids and viscosity of the coating color, the application speed, and the properties of the base sheet were observed in relation to the blade pressure and coating weight.

Over 350 trials were used in this study. The majority of these trials were carried out on the experimental coater in our cent ralresearch department. This 25-in. unit is equipped with two flexible blade coaters. One is conventional "puddle" type trailing blade while the other permits the blade angle to be varied. The maximum operating speed is about 700 f.p.m. Additional information was gained through the use of a commercial off-machine coater of approximately 70-in. maximum trim and 1500 f.p.m. maximum speed. In most instances, high solids, low viscosity coating colors utilizing synthetic binders were used. When desired, the viscosity of these colors was increased through the use of thickening agents. A few runs were also made with high solids, medium-low viscosity colors prepared with natural binders. The range of solids and viscosities covered in these trials varied from 55 to 66% and 100 to 36,000 cp., Brookfield, viscometer at 10 r.p.m. (spindles 1–6)

In all the trials the desired blade conditions were first set up on the coater and the blade then run-in (honed to the proper angle) before the actual trial was made. Coating weights were determined by monitoring with a differential beta-ray gage system. One gage head was positioned to measure the raw stock before coating, the other to measure raw stock immediately after coating. The difference between the two gage readings gave the amount of wet coating applied. This value multiplied by the per cent solids gave an accurate figure for the coating weight. In addition, the following advantages were gained from the use of the beta-ray gage system: variations in either the base stock or the coating application were detected immediately; coating weight information was available much more rapidly than would have been possible with conventional weight determinations; a permanent chart record for study of the entire run was obtained.

CALCULATION OF BLADE PRESSURE

The flexible blade as it is used in the trailing blade coater can be thought of as a cantilever beam supported at one end with a load or force applied at the other. This force is supplied by urging the blade against the backing roll causing the blade to deflect (the deflection of the blade due to the weight of the coating color in the trough was not considered here since the level of the color in the trough was maintained constant throughout these trials). The equation (*5*, *6*) for the deflection caused by the backing roll is as follows:

$$y = \frac{FL^3}{3EI} \qquad (1)$$

where

y = deflection of blade, in.
F = force causing deflection, lb.
L = blade extension, in.
E = Young's modulus, lb./in.^{2}
I = moment of inertia about z axis parallel to axis of backing roll, in.^{4}

The moment of inertia can be expressed as a function of the thickness and width of the beam, or in this case, the caliper c (in.) and trim b (in.) of the blade

$$I = \frac{c^3 b}{12} \qquad (2)$$

By combining equations (1) and (2) and transposing, the blade pressure P (per lineal inch) can be expressed as:

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$$P = \frac{F}{b} = \frac{Ec\,y}{4L^3} \qquad (3)$$

Figure 1 illustrates the terms as they are used in equation (3). L represents the blade extension and is measured along the blade from the edge of the bottom lip of the blade holder to the doctoring edge of the blade. The distance from the lip of the blade holder to the backing roll or to the surface to be doctored is represented by d. The blade deflection normal to d is denoted by y and the blade caliper or thickness by c.

DISCUSSION

The amount of coating deposited on a web of paper can be considered to be the result of four factors acting independently. The first is the force of the blade against the backing roll or doctored surface. As the pressure is increased the doctoring action is increased, and the amount of coating remaining on the paper decreases. The second factor acts in opposition to the first and is the pressure generated in the coating color by the rotating backing roll and paper. This force, referred to as the hydrodynamic pressure, tends to lift the blade and thereby to reduce the doctoring action. The net result of these two opposing forces governs the film thickness which passes beneath the blade. The third and fourth factors are well known in the trade, namely, color solids and base sheet.

The Effect of Blade Pressure on Coating Weight

When blade pressures were plotted against coating weights on logarithmic paper the resulting lines were found to be straight. Figure 2 is typical of the results which were obtained. It is an easy matter to fit such a line to an equation.

$$\log W = \log B - A \log P \qquad (4a)$$

or

$$W = B/P^A \qquad (4b)$$

where

W = coating weight, lb. per ream
P = applied blade pressure, lb. per lineal in.
A, B = constants for the system

The blade pressure is considered to be the force applied by the flexing of the blade. A represents the slope or rate of change of coating weight with changes in P. B, determined by the conventional slope-intercept method, becomes the amount of coating applied at a blade pressure of 1 lb. per lineal in. (where $\log P = 0$). A large number of runs were made to verify this relationship. The results of these showed that the relationship held true regardless of the coating solids, machine speed, viscosity, blade angle, or base stock. When these items were varied the specific values for A and B also varied.

More than one combination of blade caliper, deflection, and extension can be used to obtain a given blade pressure. Therefore, trials were made in which all variables, including blade pressure, were held constant except the means of obtaining the specified pressure. The coating weights remained unchanged. This clearly indicated that coating weight was indeed a function of blade pressure, regardless of how it was obtained.

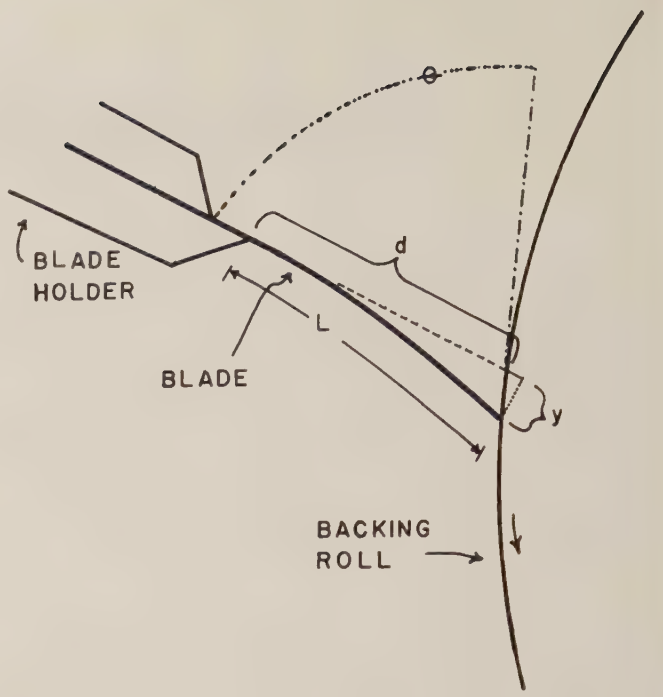

Fig. 1. Terms used in describing the trailing blade system

Hydrodynamic Pressure and Its Effect on Coating Weight

Fuller (7) discusses the pressure exerted by a wedge of fluid such as would be found in a rotating journal bearing. In this instance the rotating journal forces a wedge of oil under the journal, thereby causing the journal to be lifted. An analogous situation exists in the case of the trailing-blade coater, wherein the rotating backing roll, or more correctly the rotating paper web, forces a wedge of coating under the blade which causes the blade to lift slightly. The degree to which the hydrodynamic pressure will lift the blade will depend upon the intensity of the force—or blade pressure—to be overcome. This concept of a balance between the hydrodynamic pressure and the blade pressure provides the means of clarifying the mechanism of blade coating.

Fuller (7) reviews the development of an equation describing the hydrodynamic pressure. In simplified form this is stated thus:

$$p = \frac{us}{h^2} G \qquad (5)$$

where

p = hydrodynamic pressure
u = viscosity
s = speed
h = film thickness
G = geometry-of-system factor

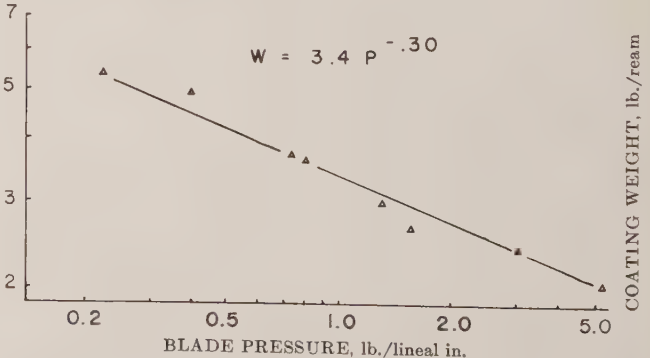

Fig. 2. Blade pressure vs. coating weight. Colors solids, 66%; viscosity, 170 cp.; speed, 600 f.p.m.

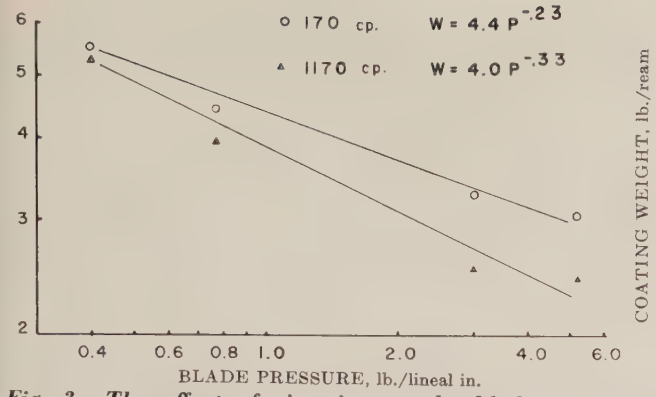

Fig. 3. The effect of viscosity on the blade pressure-coating weight relationship. Color solids, 66%; speed, 600 f.p.m.

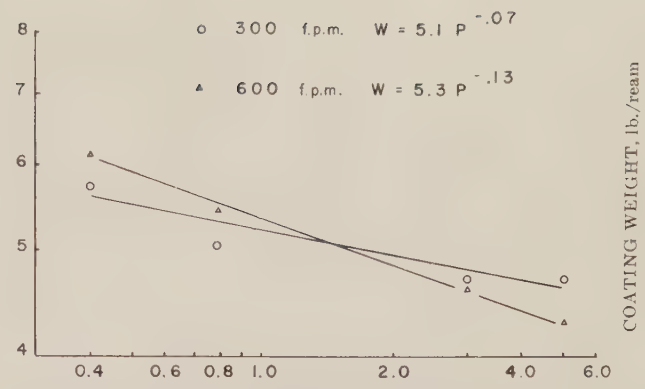

Fig. 4. The effect of speed on the blade pressure-coating weight relationship. Color solids, 66%; viscosity, 170 cp.

On this basis we might extend our analogy by saying that when the viscosity of the coating color or the speed of the paper increases, the hydrodynamic pressure will also increase. This will result in the application of higher coating weights, neglecting, for the moment, the factor of base stock.

The Effect of Viscosity and Speed on Hydrodynamic Pressure. The hydrodynamic pressure equation (5) describes the general behavior of a Newtonian system. If the color systems we dealt with behaved in this manner it would have been a simple matter to predict what weight changes would occur with a given speed or viscosity change. However, since the colors exhibit non-Newtonian flow, prediction becomes uncertain. We have not critically explored this area, other than to note that when viscosity is increased the rate of change in coating weight A also increases. A slight increase in A as the result of a sevenfold increase in viscosity is illustrated in Fig. 3. These viscosities were measured on a Brookfield viscometer at 10 r.p.m. (spindles 1 and 2), and undoubtedly are not indicative of the viscosities encountered in the high shear conditions of the coater. The measured viscosities were quite low, below 1200 cp. In the case of higher viscosity coatings, where-in the absorbency of the sheet plays a lesser role, the A term varies to a greater degree with changes in viscosity. For instance, in a situation similar to that in Fig. 3, the viscosity change was seventeen-fold and the change in A was sevenfold. In comparing color systems of considerably different composition we were not able to obtain good correlation between low shear rate Brookfield viscosity values and the A terms. Higher shear rate data would have been helpful.

From an inspection of equation (5) the effect of speed appears straight forward. An increase in speed should result in an equivalent increase in hydrodynamic pressure. Unfortunately, the manner in which viscosity changes with increasing speed, and therefore shear rates, complicates the picture considerably. Broadly speaking the effect of speed is similar to the effect of viscosity, i.e., increases in either one or both increase hydrodynamic pressure and ultimately A, the slope of the coating weight expression (see Fig. 4).

Effect of Geometry on Hydrodynamic Pressure. In equation (5) there is a term G representing the geometric configuration of the journal and the bearing, or in this case, the backing roll and the blade. If the angle θ (Fig. 1) between the tangent of the roll and plane of the blade is small the lifting force or the hydrodynamic pressure should be much greater than if the angle is large. A number of trials were carried out in which the blade angle θ was varied. The data from one such series (see Fig. 5) substantiate this. This is reflected in the increasing values of both A and B with decreasing blade angles.

Absorbency

Base Stock. The effects of paper absorbency are well known to those in the field. In brief, the higher the absorbency, the greater the quantity of total coating pickup, since total coating weight is the sum of absorbed coating plus surface coating. The base stocks illustrated in Fig. 6 represent two different levels of sizing. This difference is reflected in a change in the B term (equation 4)—the more absorbent sheet having the higher value.

Surface characteristics are also a critical factor in determining the base level of coating. A comparison of the B values obtained from the MG (Hi-fin) and MF (Lo-fin) lines in Fig. 7 illustrate to what degree the surface effects the coating weight. Other trials on MF sheets of varying degrees of finish have confirmed this.

The effect of the base sheet on the slope of the coating

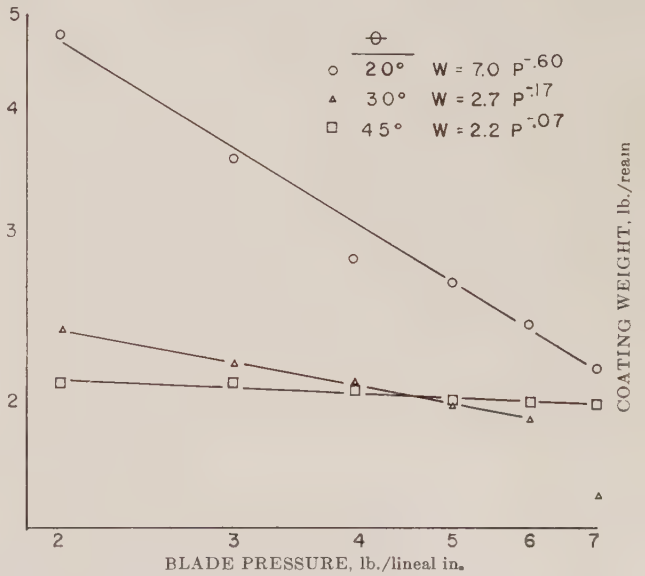

Fig. 5. The effect of blade angle on the blade pressure-coating weight relationship. Color solids, 66%; viscosity, 6000 cp.

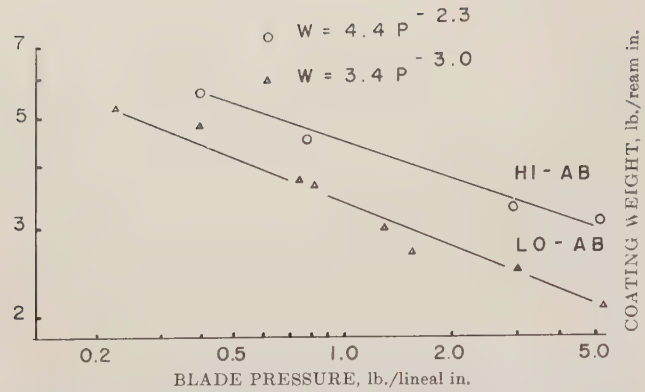

Fig. 6. The effect of base sheet absorbency on the blade pressure-coating weight relationship. Color solids, 66%; viscosity, 170 cp.; speed, 600 f.p.m.

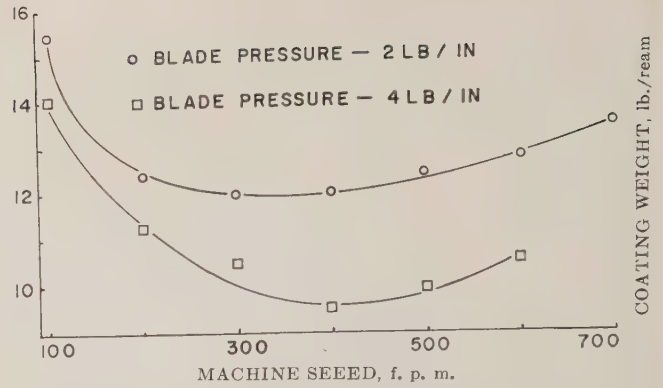

Fig. 8. The effect of machine speed on coating weight at two blade pressures. Color solids, 66%; blade angle, 20°, viscosity, 200 cp.

weight term A is not clear. It appears that as the absorbency of the sheet increases the slope A decreases. Our present feeling is that at higher blade pressures the hydrodynamic head built up in the color, and contained in the color by the blade, forces more coating into a more open or more absorbent sheet than it does a tighter or less absorbent sheet. As blade pressures are reduced, the hydrodynamic pressure at equilibrium is also reduced and less difference is noted. The net result would be a lower slope for the more absorbent sheet.

Viscosity and Speed. As would be expected, viscosity does effect the amount of coating absorbed into the sheet. Figure 3 shows that while the slopes of the lines increase with higher viscosities, the total coating weights in *this* particular case decreased (as did the values of B) because of less coating strike-in.

Speed affects absorbency by changing the effective viscosities of the coating with changing shear rates. Speed further affects the amount of coating applied by altering the time interval available for coating penetration. In this light, one would expect the coating weight to decrease as the machine speed is increased. Such is the case when the blade pressures are relatively high (see Fig. 4). However, as discussed before, at the lower blade pressures the increased hydrodynamic pressure due to speed is able to lift the blade. Therefore, the loss due to absorption is overshadowed by the increased amount of surface coating. Accordingly, the value of the B term may increase or decrease as speed increases, depending upon the relative significance of the absorbed coating and the net result of applied blade pressure and hydrodynamic pressure.

As an additional example of how coating weight changes with speed, a series of trials were made in which the speed was varied over a wide range while the blade pressure was held constant (see Fig. 8). First, coating weight decreased to a minimum because of the reduction in absorbed coating with higher machine speeds. This was followed by increases in coating weight as the hydrodynamic pressure built up with still higher machine speeds. Second, the speed at which the minimum coating weight occurred moved upward with higher blade pressures. This again showed that coating weight is related to the net balance of blade pressure and hydrodynamic pressure.

In the above trials a relatively low blade angle was used and the effect of hydrodynamic pressure was thereby intensified. A similar series of runs were made on a commerical off-machine coater using a conventional puddle-type blade and blade angle. In this instance, the speeds necessary to lift the blade were much higher since the geometry of the blade reduced the intensity of the hydrodynamic pressure at any given speed.

Coating Solids. The general effect of increasing coating color solids is as would be expected. Figure 9 illustrates the changes which occur. Both the A and B terms of the equation increase as solids increase. The B term is affected primarily by the higher per-

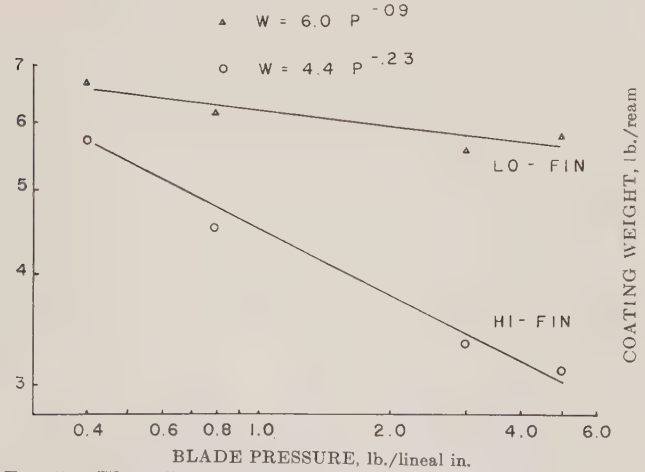

Fig. 7. The effect of sheet finish on the blade pressure-coating weight relationship. Color solids, 66%; viscosity, 170 cp.; speed, 600 f.p.m.

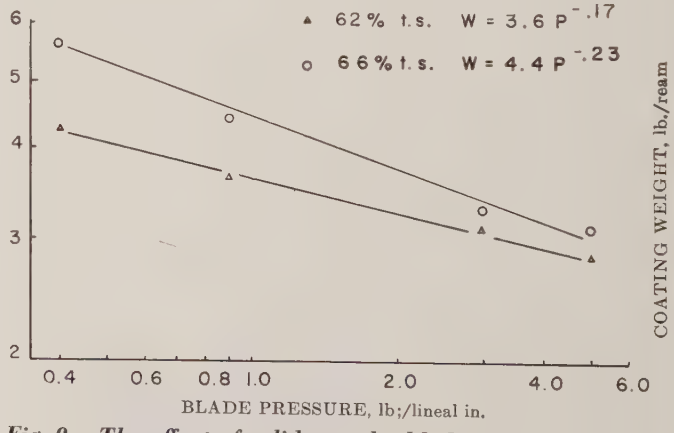

Fig. 9. The effect of solids on the blade pressure-coating weight relationship. Speed, 600 f.p.m.; viscosity, 170 and 90 cp.

centage of solids in the coating while the A term is probably affected by the resulting increase in color viscosity.

SUMMARY AND CONCLUSIONS

A method for determining the blade pressure applied by a flexible blade coater has been described. For a given operating speed and coating color formulation, variations in blade pressure will produce predictable changes in coating weight. These changes take the form of equation (4b).

At our present level of knowledge the values of the terms A and B must be determined experimentally. Once established for a system where machine operating speed and color characteristics are held constant, the necessary change in blade pressure to obtain a desired change in coating weight can be readily calculated. On the other hand, it is not possible to calculate the required blade pressures for a different system without first experimentally establishing values for A and B.

To date our work has shown the following changes to occur in the basic formula.

As viscosity or machine speed increases A increases; B may increase or decrease depending upon the absorbency of the sheet and the net effect of applied blade pressure and the hydrodynamic pressure.

As color solids increase both A and B increase.

As absorbency and/or roughness increase A appears to decrease slightly. B increases.

As the angle of the coating blade to the tangent of the backing roll decreases A and B increase.

Although there is still much to learn before an expression is available for predetermining constants for a new system, we are still able to discuss the interplay of the variables in the system. This has been useful to us in obtaining a clearer understanding of the flexible blade coater. We believe that others will also find this to be true.

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Received June 29, 1960. Presented at the 11th Coating Conference of the Technical Association of the Pulp and Paper Industry, held in Chicago, Ill., May 23–25, 1960.

The Champflex Coater

CHARLES G. WHELPTON

One of the more recent developments in the field of coating paper and board is the Champflex coater. In the general category of trailing blade coaters, the Champflex uses a small rotating rod held in a spring mounting. Rotating against the direction of sheet travel, the rod has the ability to doctor coatings without a tendency for foreign particles to lodge behind the blade, causing streaks. The coater is relatively easy to operate, fairly inexpensive to build, and permits simple coating preparation and handling techniques. A single coating application can apply a weight of from 3 to 15 lb. per ream (25 × 38—500) per side at solids ranging up to 65%. The versatility of the Champflex coater is emphasized by its successful use both on- and off-machine, not only to apply pigmented coatings, but also to apply nonpigmented materials which could not be done successfully by other means.

In the search for simpler, less expensive, and more efficient machine coaters for paper and board, Champion feels that it has made a significant breakthrough. The Champflex® coater, an outgrowth of the development now familiarly known as the Champion machine-coating process, is proving to be an effective answer to a number of the problems in this constantly expanding field. Although it has been in use in our own mills for several years and recently has been licensed to others, the operating details of the Champflex coater have never been disclosed publicly before.

To put the Champflex coater development into proper perspective, the development of the Champion process with which it has much in common will be reviewed.

As can be seen in Fig. 1, the Champion process itself employs a very simple coater. The principle involves the application of an excess of coating to the web where a filter cake forms as the water drains into the paper. Next, a doctor blade removes the surplus coating, leaving the semisolid filter cake on the surface of the web. In addition to being inexpensive and easy to operate, the Champion process does a good job when it is properly used.

As an indication of its acceptance, there are over 80 paper and board machines in 13 countries, each having from one to four Champion coaters installed. But use of the Champion process has been somewhat limited because the web must have a moisture content of 35 to 50% at the coaters. Otherwise the paper or board is not flexible enough to fit the blade properly and an uneven doctoring action results. With such a damp and correspondingly weak web, it is difficult to run in excess of 1000 f.p.m. on papers weighing 50 lb. or less per ream (25 × 38—500) having 50% or more groundwood in the furnish. Because of that, efforts have been directed toward development of a more versatile machine coater.

Out of the first development efforts came a trailing blade-type coater which troweled the coating, producing an exceptionally flat, smooth surface on a web containing from 5 to 15% moisture. However, this coater was plagued by the tendency of the blade to scratch the coated surface. Several types of flexible

Charles G. Whelpton, Assistant Manager, European & Licensing Division, The Champion Paper & Fibre Co., Hamilton, Ohio.

®Registered trademark of the Champion Paper and Fibre Co.

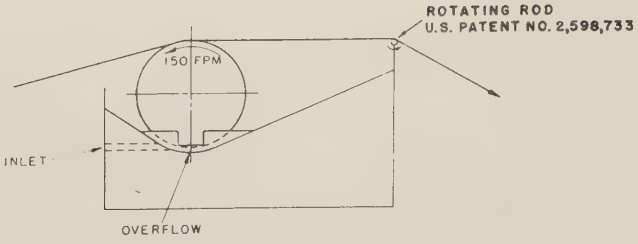


Fig. 1. The Champion machine coating process

and rigid coater blades were tried but with disappointing results. The biggest problems were scratches from foreign particles which would catch between the blade and the web, and excessive blade wear. Further development work led to the invention by Edgar Warner of Champion's Research & Development Division, of a small diameter rotating doctor bar held in a spring mounting as shown in Fig. 2.

The body of the blade consists of a spring steel strip approximately $3^1/_2$ in. wide by 0.025 in. thick. Along one edge are welded two thin strips shaped to hold the rotating bar.

In 1956, U. S. pat. 2,729,192, which describes this coater blade assembly, was issued and assigned to Champion. It was christened the Champflex blade. It is the heart of the Champflex coater, and as mentioned at the outset, this is the first public disclosure of its operating details.

Early in 1958, Champion was approached by a mill that wanted to coat bleached board. The goal was a good print quality with a minimum of coating, since coated bleached kraft board seldom sells for a higher price than the same board uncoated.

It seemed that a variation of our trailing blade-type coater located between machine calenders would be a satisfactory solution. Pilot-plant trials were made with the flexibly held rotating doctor and resulted in the arrangement as shown in Fig. 3. Two rolls were used to apply coating to the web. The excess was then doctored by the rotating blade held by the flexible mounting. The steel backup roll was driven by the web which it kept in contact with the blade to insure an even coating application.

While belonging to the general class of trailing blade coaters, the Champflex is unique in having the characteristic feature of the small rotating rod held in a spring mounting. The rod, which is chrome plated to give longer service, rotates at 10 or 20 r.p.m. against the direction of web travel. As the rod turns, it is continually wiped clean by the stainless steel strips which form the socket or groove which holds it. Consequently, foreign particles do not tend to lodge between the rotating edge of the blade and the web. Instead, they are ejected from the nip and washed away by the fluid coating doctored from the web. The result is a trailing blade coater which will operate with a minimum of streaks and scratches.

Rod sizes of both $^1/_4$ and $^3/_8$ in. diam. are in use today. As one might expect, the larger the blade, the heavier the coating application and the greater the tendency for a pattern to be formed. The body of the blade is clamped in a holder which has adjustment screws spaced a short distance apart, across the width of the machine. These screws can be used to help bring the blade into proper position relative to the web

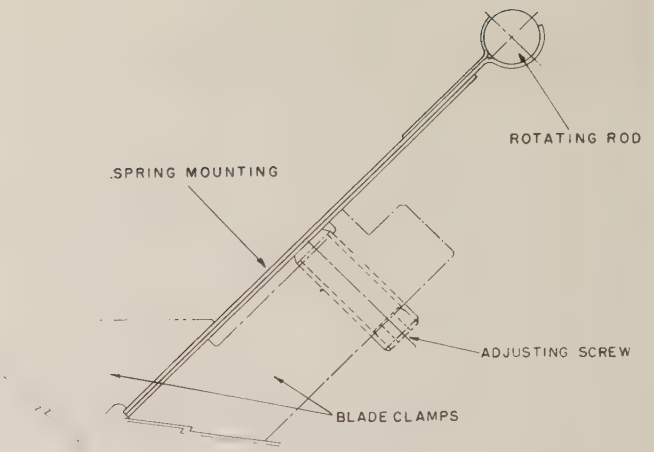


Fig. 2. The Champflex coater blade; U.S. patent no. 2,729,192

to doctor it uniformly. That is, the pressure along the length of the blade can be varied to cause the rod to conform as closely as possible to the cross machine profile of the web.

Furthermore, the rotating rod will not overheat or warp as will a razor-thin blade if it happens to run against the dry web for more than a few seconds before the coating is applied.

Blade life varies, depending on such factors as the coating abrasiveness, rod size, blade pressure, machine speeds, and grades. One paper machine operating at 1000 f.p.m. commonly gets from 1 to 2 weeks' service from a blade. Longer life is the rule on slower running board machines.

The principal causes of blade trouble are lack of maintenance and rupture of the chrome plate. If there is any question about the condition of a blade, it should be replaced, spring mounting, rod and all, during regularly scheduled shutdowns or before the start of a coating run. However, if rod failure should occur during operation, a new rod can be substituted for the worn one without removing the spring holder. As a result, down time can usually be held to 2 or 3 min.

The applicator rolls are commonly run against the

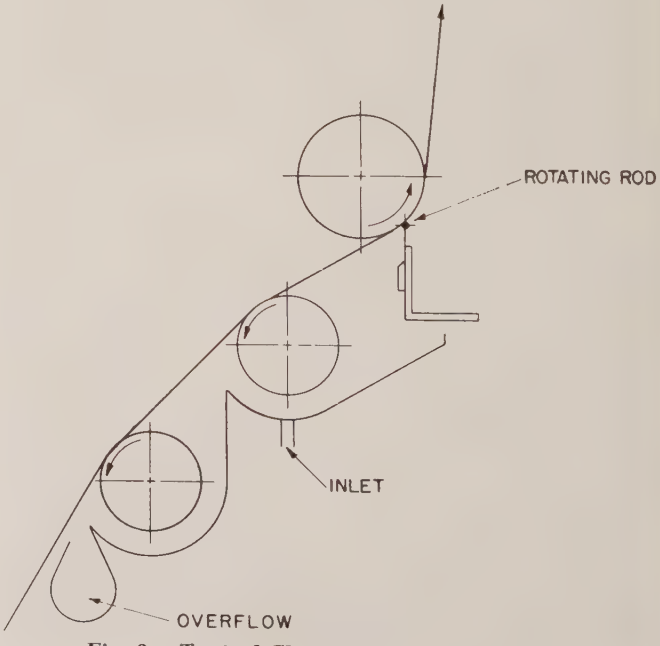


Fig. 3. Typical Champflex coater for board

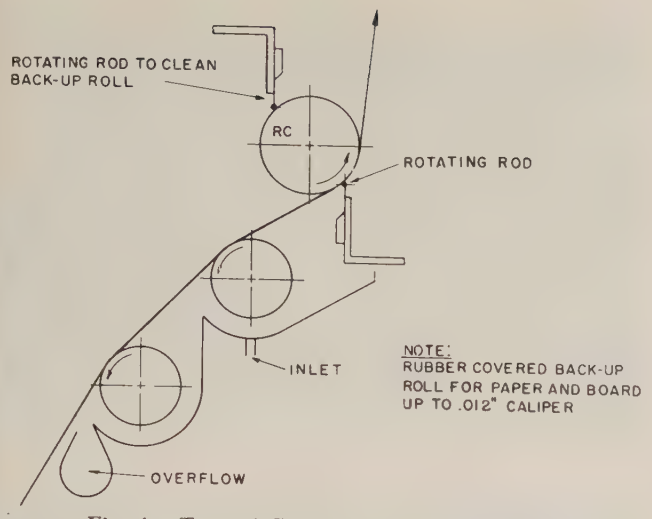


Fig. 4. Typical Champflex coater for paper

direction of web travel at a surface speed of about 150 f.p.m. They are chrome plated to facilitate washups which are generally not required more often than once a day. In addition to the flexibility of the holder for the rotating rod, we have found there must be some resilience in the web itself or in the backup roll to reduce the danger of the web snapping as it passes between blade and the backup roll.

As a result of coating trials on board in excess of 10 to 12 points in caliper, we found that sufficient resilience or cushion was supplied by the board itself. That made it possible to use a stainless steel backup roll without a helper drive. Since the roll slips somewhat, as it is driven by the web, it is self-cleaning, to a degree. However, large coating deposits should either be washed- or scraped-off.

Because papers weighing less than about 100 lb. per ream (25 × 38—500) have little built-in cushion, they require a rubber-covered backup roll. Also, since there is no slippage between the rubber surface and the web, means had to be provided for keeping the roll clean. We have successfully employed a second rotating doctor blade.

Figure 4 shows the arrangement of the second blade. The blade is lubricated to prevent it from burning up the rubber roll. This is done by running either a pond of water or coating behind it.* Because of the load imposed by the doctor on the rubber-covered backup roll, a helper drive is required.

Complicated and expensive coating preparation and handling operations have not proved to be essential to the operation of the Champflex coater. Low shear mixers of the disk and propeller type are suitable to prepare coatings. Eighty- or 100-mesh screens are adequate to screen coating into the makeup tanks. Additional screening is optional.

The Champflex coater has been operated with a variety of coatings having a wide range of characteristics. Coatings having moisture-free solids of up to 62 or 63% have run well, but the usual range is from 50 to 55%. Coatings with Brookfield viscosities up to 11,000 cp. (no. 5 spindle, 20 r.p.m., 80°F.) have been satisfactory on board although lower viscosities, 300 to 1000 cp., are the rule for papers. Speeds of operation have varied from 400 to 1000 f.p.m. for paper and 175 to 500 f.p.m. for board.

Taylor, W. P., U. S. Pat. 2,534,321 (Dec. 21, 1950)

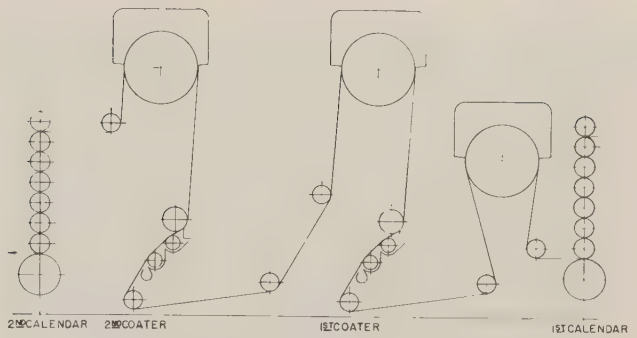


Fig. 5. Typical layout Champflex coaters

Coat weights have varied depending on such factors as the stock, solids, viscosity, rod diameter, and number of applications. One coater can apply from 3 to 15 lb. of coating per ream (25 × 38—500) on uncoated stock, or from 1 to 7 lb. per ream on precoated stock.

As is the case with most coaters, the coat weight is usually controlled by variations in coating formulation. A small measure of immediate control can be exercised by varying the blade pressure which would normally range from 3 to 7 lb. per lineal inch. However, if too great a variation of coat weight were attempted in this manner, there are two risks. One is that of pinching the web with excessive pressure and breaking it. The other is, if insufficient pressure is used, too much coating may be left on the web which will smear turning rolls or driers.

Ordinarily, we favor the use of two lightweight coating applications in preference to a single heavy coat. The priming action of the base coat seems to be particularly desirable. Two coats permit the use of different coating formulas for the base and top coats.

It is considered good coating procedure to smooth the uncoated surface as much as practicable prior to coating. It is also customary to prepare bleached board for coating by size press and calender box applications. The Champflex coater is no exception to these rules. A typical layout of two Champflex coaters on a bleached board machine is shown in Fig. 5.

Two coaters are shown between the first and second calenders. After each coater drying capacity is required which may consist of standard driers either alone or in conjunction with one of the high velocity air types recently developed.

PRODUCT APPLICATION

Turning from the mechanics of the Champflex coater, let us consider some of the end-products. Figures 1 through 9 are photomicrographs (magnification 27×) showing specimens of Champflex coated boards.

Figure 6 shows 0.013 bleached cylinder board with the uncoated sheet on the left, a sheet having one Champflex coat of 3.3 lb. per ream (25 × 38—500) in the center, and a sheet with two Champflex coats totaling 6.0 lb. per ream on the right. Coat weights were determined by ashing the raw stock, the coating, and the coated sheet. Three-eighths-in. diam. blades were used in both coaters.

We have been rather fortunate to have had the opportunity for extensive mill trials using a Champflex blade in a conventional trailing blade coater. The results were quite encouraging. Figure 7, shows the comparison between fourdrinier board coated with a $^3/_8$-in. diam. Champflex blade and with a standard

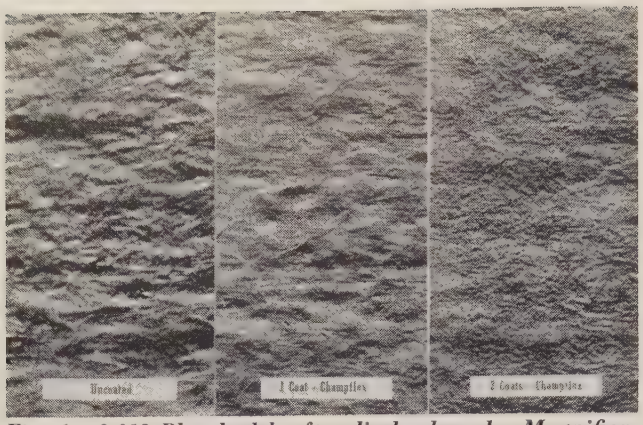


Fig. 6. 0.013 Bleached kraft cylinder board. Magnification ×27

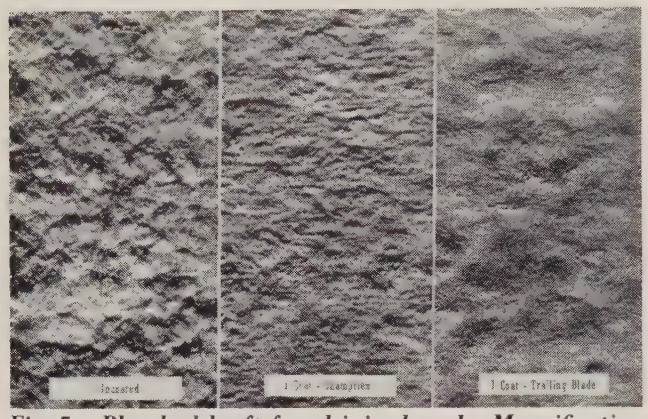


Fig. 7. Bleached kraft fourdrinier board. Magnification ×27

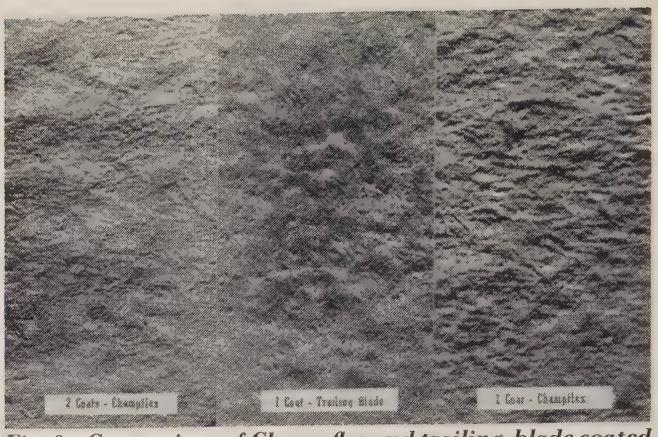


Fig. 8. Comparison of Champflex and trailing-blade coated bleached kraft board. Magnification ×27

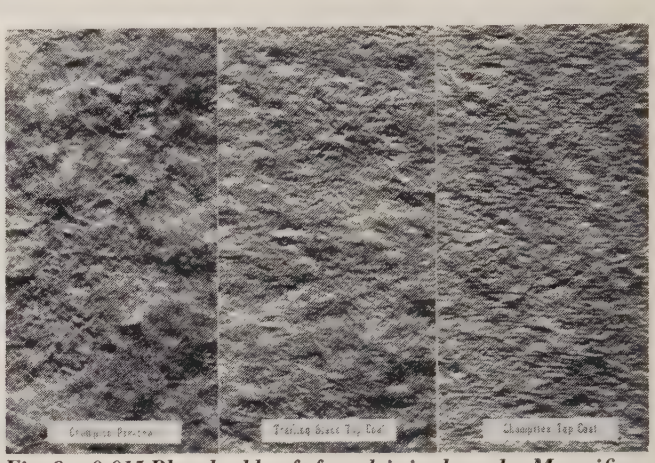


Fig. 9. 0.015 Bleached kraft fourdrinier board. Magnification ×27

trailing blade. The tests were made on the same coater. The only difference was the substitution of blades. The trailing-blade coated board tended to have streaks in the coating. Only when it operated perfectly did the trailing blade produce a flatter, smoother surface than has been obtained at that mill with the Champflex coater.

The Champflex blade, applying about 5.9 lb. per ream (25 × 38—500), produced a sheet which was virtually free of streaks, and the board was substantially uniform in quality from beginning to end of the run. Use of small diameter rotating rods and the associated higher blade pressures in pilot plant trials have enabled the Champflex blade to apply a flat, smooth coating as well as one that is streak-free. Mill trials are expected to verify that on a production basis.

Figure 8 compares a competitive trailing blade coated fourdrinier sheet, generally conceded to be one of the best in the country, with two of the Champflex samples from the previous slides. On the left is the double coated Champflex cylinder board, and on the right the fourdrinier board coated with a Champflex blade substituted in a trailing blade coater.

Figure 9 shows 0.015 fourdrinier boards which were precoated with a Champion coater. Some of the stock was top-coated on a large conversion trailing blade coater, and some on a Champflex coater using a $^1/_4$-in. diam. rod. Visual examination of the board with the Champflex top coat shows it to have appreciably better coating coverage and a smoother surface than the board with the trailing blade top coat. The print results confirmed those conclusions.

At present, the Champflex coater has been licensed in the United States and two other countries. There are three installations operating on printing papers, and two on a variety of bleached board grades with a third board installation scheduled early in 1961. Last, but not least, a conversion roll coater of conventional design has been equipped with a Champflex blade under a license agreement. In this case, nonpigmented coatings could not be applied successfully by any other means. Further developments along this line are anticipated in the conversion coating field.

SUMMARY

The Champflex coater is in some respects similar to the Champion coater. Each is capable of producing excellent quality depending on operating conditions. The important point to remember is that both are relatively simple, inexpensive to build, and easy to operate. At the same time, the Champflex coater is a decided step forward since it is adaptable to a wider range of applications.

The ultimate capabilities of the Champflex coater are not yet known. While results achieved in trials and mill runs have been encouraging, there has been less than six months' commercial experience with the coater on other than coat-one-side printing papers. We have great hopes for the future development of the Champflex coater with a wide variety of coatings for paper and board, both on- and off-machine.

Received June 6, 1960. Presented at the 11th Coating Conference of the Technical Association of the Pulp and Paper Industry, held in Chicago, Ill., May 23–25, 1960.

ASSOCIATION NEWS AND EVENTS

National Conferences

1961

46th Annual Meeting, Feb. 19–23, 1961, Commodore Hotel, New York, N. Y.

Twelfth Coating Conference, May 22–24, 1961, Statler-Hilton Hotel, Buffalo, N. Y.

Twelfth Testing Conference, Aug. 15–18, 1961, Queen Elizabeth Hotel, Montreal, Que.

Eleventh Corrugated Containers Conference, Sept. 11–13, 1961, St. Francis Hotel, San Francisco, Calif.

Fourth Mechanical Pulping Conference, Sept. 19–21, 1961, Edgewater Beach Hotel, Chicago, Ill.

Symposium on Formation and Structure of Paper, Sept. 25–29, 1961, B.P.B.M.A., Oxford, England.

Sixteenth Plastics-Paper Conference, Oct. 9–11, 1961, French Lick Sheraton Hotel, French Lick, Ind.

Sixteenth Engineering Conference, Oct. 15–19, 1961, Shoreham Hotel, Washington, D. C.

Fifteenth Alkaline Pulping Conference, Nov. 1–3, 1961, Rice Hotel, Houston, Tex.

1962

47th Annual Meeting, Feb. 18–22, 1962, Commodore Hotel, New York, N. Y.

Thirteenth Coating Conference, May 14–16, 1962, Netherland-Hilton Hotel, Cincinnati, Ohio.

Thirteenth Testing Conference, Sept. 18–20, 1962, Benjamin Franklin Hotel, Philadelphia, Pa.

Seventeenth Engineering Conference, Oct. 14–19, 1962, Queen Elizabeth Hotel, Montreal, Que.

Twelfth Corrugated Containers Conference, Oct. 23–26, 1962, Statler-Hilton Hotel, Boston, Mass.

Sixteenth Alkaline Pulping Conference, 1962, Savannah, Ga.

1963

Fourteenth Coating Conference, May 19–22, 1963, French Lick Sheraton Hotel, French Lick, Ind.

Thirteenth Corrugated Containers Conference, Oct. 22–25, 1963, Statler-Hilton Hotel, Detroit, Mich.

46th Annual Meeting

The Hotel Commodore, New York, N. Y., will once again be the scene for TAPPI's Annual Meeting. The 46th Annual Meeting will be held from Feb. 20 to 23, 1961, and presently twenty-four sessions are being planned in addition to meetings of nearly all of the standing committees.

The meeting is being planned in cooperation with the technical committees and divisions of the Association by the headquarters staff. A. J. Winchester, Technical Secretary, is acting as general chairman, and J. W. Field is serving as arrangements chairman.

The following committees are planning to sponsor sessions at the meeting:

Coating and Graphic Arts Division
- Graphic Arts Committee (2)

Corrugated Containers Division (3)

Engineering Division
- Corrosion Committee (2)

Paper and Board Mfg. Division
- Cylinder Board Committee (2)
- Fourdrinier (1)
- Structural Fibrous Materials Committee (1)
- Water Committee (1)

Pulp Manufacture Division
- Alkaline Pulping Committee (1)
- Chemical Products Committee (1)
- Dissolving Pulps Committee (2)
- Pulp Purification Committee (2)
- Sulfite Pulping Committee (1)

Research and Development Division
- Microbiological Committee (1)
- Statistics Committee (2)

Testing Division
- Adhesives Testing Committee (1)
- Optical Methods (1)

Anyone wishing to offer a paper for presentation at the meeting should get in touch with TAPPI headquarters.

Hotel reservations should be addressed directly to the Hotel Commodore, New York 17, N. Y.

Twelfth Coating Conference

The Twelfth Coating Conference will be held May 22–24, 1961, at the Statler-Hilton Hotel in Buffalo, N. Y.

R. W. Martinek, Kimberly-Clark Corp., Neenah, Wis., is general conference chairman; C. G. Whelpton, Champion Paper and Fibre Co., Hamilton, Ohio, is technical program chairman; and C. E. Mikel, Corn Products Sales Co., Buffalo, N. Y., is local arrangements chairman.

R. W. Martinek

C. G. Whelpton

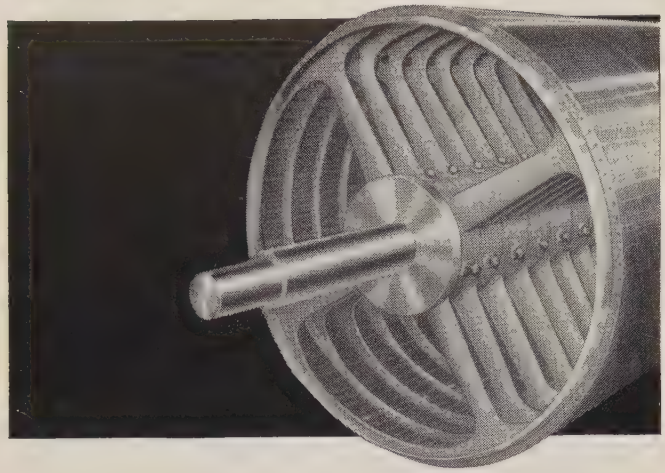
Plans are being made for a comprehensive technical program and also for the large registration which has been the case during the last several Coating Conferences.

Ninth Annual Joint Statistics Courses

The Ninth Annual Joint TAPPI-CPPA Courses in Statistical Methods for the Paper Industry were held at Brevard College, Brevard, N. C., Aug. 8 through 19, 1960.

As is accustomed practice, the courses were held in two different sessions—running concurrently. The first was a basic or elementary course designed for people who wanted to learn about the basic concepts of statistics and their applications in the paper industry. The second was an advanced course design for people having a previous background of experience with applications of statistical methods.

Sandy Hill cylinder moulds



Sandy Hill CYLINDER MOULDS have streamlined spiders on a large-diameter shaft with anti-friction bearings. Special features of spider construction insure even and firm support of the wire backing and facing cloth and greatly reduce agitation within the mould.

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HUDSON FALLS, N. Y.

The enrollment list included a number of representatives from the South—as far south as Texas—and from as far north as Calais, Me., in the United States and Trois-Riviéres, Que., in Canada.

Preparation of the outlines for the two courses, as well as general supervision of instruction was in charge of Professor Robert J. Hader of the Institute of Statistics of North Carolina State College. The instructing staff included, in addition to Professor Hader, A. H. E. Grandage of North Carolina State College, Carl E. Noble of the Kimberley-Clark Corp., Neenah, Wis., Allan E. Paull of the Abitibi Power and Paper Co., Ltd., Toronto, Ont., and W. R. Grace & Co., Cambridge, Mass.

The texts used were Davies's "Statistical Methods in Research and Production," for the basic course, and Davies' "Design and Analysis of Industrial Experiments," for the advanced course. In addition, the basic course was supplemented with introductory material on design of experiments, and the advanced course was supplemented with lectures by Dr. Paull on applications of linear programming.

Through the courtesy of the Olin Mathieson Chemical Corp., Ecusta Paper Div., the facilities of Strauss Park, which is owned and operated by this firm, were made available to the students and faculty for a picnic and for other recreation. Plant visits were also made to the Ecusta Paper Div.'s plant at Pisgah Forest, N. C. and to the plant of the Champion Paper & Fibre Co., Canton, N. C.

A banquet was held on Thursday evening, August 18. R. G. Macdonald, treasurer and editorial director of TAPPI, welcomed the students on behalf of TAPPI and CPPA, and gave a very interesting talk describing his recent overseas experience, putting particular emphasis upon the growing interest in statistical methods and statistical quality control in the worldwide paper industry. Professor Hader, on behalf of the Institute of Statistics, passed out certificates from the Institute to all persons attending the course.

Row 1—(left to right): Simerly, Robert L., Union Bag-Camp Paper Corp., Savannah, Ga.; Maskel, Robert H., Kimberly-Clark Corp., Neenah, Wis.; Crutchfield, Douglas, West Virginia Pulp & Paper, Summerville, S. C.; Hader, R. J., N. C. State College, Raleigh, N. C.; Renner, M. S., Dewey and Almy Chemical Co., Cambridge, Mass.; Macdonald, R. G., Editorial Director, Tappi, New York, N. Y.; Grandage, A. H. E., N. C. State College, Raleigh, N. C.; Paull, Allan E., Abitibi Power & Paper Co., Toronto, Ont.; Ros, Thomas C., International Paper Co., Natchez, Miss.; Dickenson, William L., Buckeye Cellulose Corp., Memphis, Tenn.; Abrams, Warren E., Hudson Pulp and Paper Co., New York, N. Y.

Row 2—(left to right); Tarantino, Michael J., International Paper Co., Glen Falls, N. Y.; Helms, F. S., American Viscose Corp., Meadville, Pa.; Tarazi, David S., Southland Paper Mills, Lufkin, Tex.; Duffy, Michael G., Anglo Paper Products, Quebec, Ont.; Reynolds, Arthur E., West Virginia Pulp & Paper, Williamsburg, Pa.; Levesque, Renaud, Donnacona Paper Co., Donnacona, Que.; Hooper, R. L., Olin Mathieson Chemical Corp., Pisgah Forest, N. C.; Guenette, Jean, Rolland Paper Co., St. Jerome, Que.; Houppert, Gerald E., Knowlton Brothers, Watertown, N.Y.; Sands, G. S., E. I. du Pont de Nemours & Co., Camden, S. C.

Row 3—(left to right): MacMillan, F. A., Abitibi Power & Paper Co., Sault Ste. Marie, Ont.; Stevens, John L., International Paper Co., Georgetown, S. C.; Farrell, Joseph B., American Machine & Foundry Co., Springdale, Conn.; Norman, W. A., The Chemstrand Corp., Decatur, Ala.; Lamothe, Jacques, The Papermaking Institute, Trois-Riviéres, Que.; Ferguson, Ben C., International Paper Co., Mobile, Ala.; Hubbe, Paul D., Great Northern Paper Co., Millinocket, Me.; DeFelice, Vincent N., St. Croix Paper Co., Woodland, Me.; Starnes, Eugene, N. C. State College, Raleigh, N. C.

Row 4 and 5—(left to right): Slater, Herbert R., St. Croix Paper Co., Calais, Me.; Jolliff, C. C., Olin Mathieson Chemical Corp., Pisgah Forest, N. C.; Clark, C. L., West Virginia Pulp & Paper, Charleston, S. C.; Johns, E. C., Olin Mathieson Chemical Corp., Pisgah Forest, N. C.; Mole, Joseph F., West Virginia Pulp & Paper, Charleston, S. C.; Wentworth, Robert B., American Newspaper Publishers, New York, N. Y.

Not present: C. E. Noble.

46th

Annual Meeting

TAPPI

Hotel Commodore

New York, N. Y.

Feb. 19–23, 1961

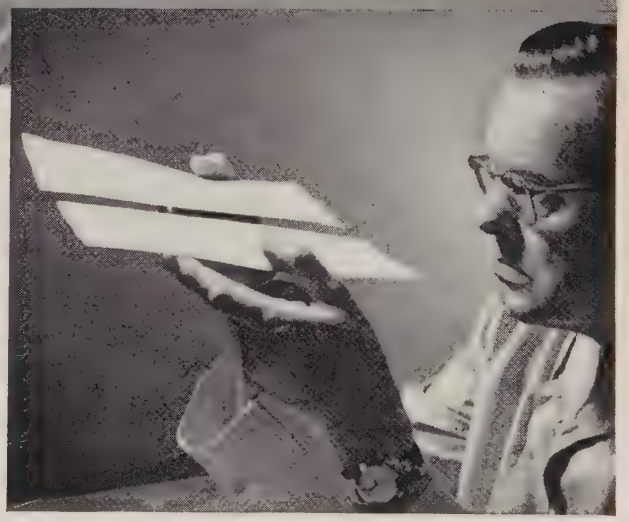
From the Paper Research Laboratory of The New Jersey Zinc Company
ONE *of a Series of Test Procedures on Horse Head Titanium Dioxide*

Supercalendering is one of the important steps in the preparation of test samples for use in the study of characteristics of coated paper.

SUPERCALENDERING

Characteristics of coated papers—uniformity and smoothness of surface, gloss, opacity, printability, and show-through are studied continuously in the paper laboratory of The New Jersey Zinc Company. An important phase of the program involves a study of the effect of supercalendering on such properties of coated papers pigmented with various types of titanium dioxide.

These investigations have developed and will continue to develop new and practical information on the application of titanium dioxide in coated papers. Too, they are providing a constant check on the basic properties of Horse Head titanium dioxide to assure the highest standards of pigment quality and uniformity.



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TAPPI NOTES

Highlights of the September Executive Committee Meeting

The Association's bylaws have been amended to conform to recent changes in the constitution involving classes of membership. Overseas members will be assigned to other classes, and a mailing fee will replace the former differential between the dues of overseas and domestic members.

The publication of manuscripts presented at meetings of the Association is to be regulated in accordance with these procedures:

1. The Association reserves the right to publish all papers presented at its national meetings. A national meeting is any Association meeting other than those of local sections and districts.
2. Papers presented at national meetings or submitted voluntarily for publication become the property of the Association to be published in its official publications and are not to be published elsewhere unless permission is first obtained from the Association.
3. Reports on such papers may be published in other journals at any time after the papers have been presented at Association meetings. Such reports may not include more than one-quarter of the text material.
4. If a paper is not accepted for publication by the Association, it will be returned promptly to the author with a letter releasing it for any other use. If the author chooses, he may consult with the Association staff about revisions which might make the paper suitable for publication by the Association.
5. A paper presented at a meeting of an Association local section or district may be offered for publication in *Tappi* or in other journals, at the discretion of its executive committee or officers.
6. The Association reserves the right to refrain from publishing any paper that has already been published in another magazine.
7. Permission to reprint papers published in *Tappi* must be obtained from the *Tappi* Editor. Such permission will normally be granted, provided that proper acknowledgment of this source is given in the reprint.

The Association office will assist editors of other magazines in obtaining copies of the manuscripts presented at national meetings. Authors of national meeting papers will be instructed to refer all requests for such copies to the Association's headquarters office, so that it can handle the distribution on an equitable basis.

Since the disposition of a paper presented at a local section or district meeting is to be determined by the group's officers or executive committee, editors of other magazines will be urged to channel their requests for copies of such papers through these men rather than approaching the authors directly.

Cumulative TAPPI bibliographies will be discontinued in favor of the annual publications listing references to patents as well as to books and periodicals. Thus 1960 references will appear in an annual edition rather than in a 1956–1960 cumulative volume.

Metric units of measurement will be preferred, wherever practical, in future revisions or additions to the Association's standard testing procedures. Where English units are necessary, their metric equivalents should also be included wherever possible.

Services to sustaining members will be expanded, so that each sustaining member may receive, upon request, a complimentary bound volume of *Tappi* Technical Sections beginning in 1961. An incoming sustaining member may also receive, upon request, a complimentary set of Standards, Data Sheets, and Routine Control Methods.

"The College Textbook of Pulp and Paper Manufacture" will be extensively revised for 1961 publication between hard covers.

Michael Kouris has been named Technical Editor on the Association staff. In this capacity he will be responsible for editing *Tappi* Technical Sections, monographs, and other selected publications.

Future conference budgets may, upon proper approval, include the expenses of a general reception immediately prior to the conference banquet.

PHILIP E. NETHERCUT
Executive Secretary

"DYLEX® K-52 latex reduces titanium content 40% in our paperboard coating!"

says Bert Bushnell, Technical Supervisor for New Haven Board & Carton Company.

"This outstanding latex has saved us a lot of money," says Mr. Bushnell. "We've reduced costly titanium content 40%, substituted much less expensive clay coatings, and yet we've improved our coating brightness by 4 points. Another thing we like about Koppers is their customer service. Shipments are always on time and Koppers is ready to help us in our product development and production techniques."

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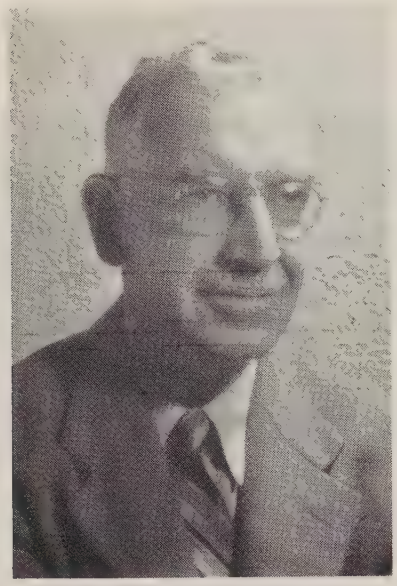
Get complete information about latex coating. Call our local sales representative or write for our free pamphlet on DYLEX K-52 . . . complete with charts and test data. Koppers also produces DYLEX® K-54 and DYLEX® K-85 for the paper industry. Contact Koppers Company, Inc., Plastics Division, Pittsburgh 19, Penna.

KOPPERS PLASTICS KOPPERS

TAPPI PROFILES



JAMES D'ARGAVILLE CLARK, Chairman of the TAPPI Standards Committee, is Professor of Pulp and Paper Science at Oregon State College, and a Consulting Engineer to the Paper Industry.

Born in Scotland in 1901, he spent his youth in South Africa (1903–19) and matriculated at the Grey Institute High School, Port Elizabeth, S. A., in 1916.

While his father was in France as a surgeon in World War I, he ran his cattle, sheep, and ostrich ranch for a year but liked the steam-driven irrigation plant better, and decided to be an engineer. Spending six months learning plumbing, blacksmithing, and electrical work in Pretoria, S. A., he then went to the University of Capetown and received an Intermediate B.Sc. in Engineering, in 1919. On his return to England he entered the University of London and graduated B.Sc. in Civil and Mechanical Engineering, in 1922.

His career in the paper industry began soon after graduation for he became an apprentice engineer at Masson Scott & Co., paper mill engineers in London, 1923, and he also attended night school in papermaking technology at the City and Guilds of London Institute. In 1924 he obtained a first class final diploma in paper mill chemistry.

An apprentice papermaker for a year with Hendon Paper Works, Sunderland, England—esparto pulp and fine papers—he became assistant to the chief electrical engineer at Edward Lloyd Ltd., in Kent, now part of Bowaters Paper Mills. In 1925 he won one of the two annual Sir Robert Blair Fellowships for a year's study abroad in applied technology, and came to Canada and the United States for 15 months to study the manufacture of wood pulp. While in North America he visited over 80 pulp and paper mills; spent about eight months as chemist at Canada Paper Co. when the Keebra (sodium monosulfite) process with complete recovery system was first tried. After making an excellent pulp initially, in a couple of weeks the recycled liquor gradually made the pulp darker and darker until it was jet black and, after his being nearly killed with hydrogen sulfide gas, the process was abandoned.

During this period he also instituted control tests in the groundwood mill and learned at first hand the unreliability of the freeness test. He also developed the prototype of the British sheet machine and method as a composite of the various test methods and equipment seen in a number of laboratories, especially in the Pulp & Paper Research Institute of Canada, Montreal, then the Canadian Forest Products Laboratory —the Date sheet machine—and at Wayagamack, the Wilen sheet machine.

Returning to England in March, 1926, he joined Bowaters Paper Mills, as their first chemist and technical man. It was Arthur Baker, then managing director of Bowaters and founder of the Technical Section of the British Pulp and Papermakers Association, who then formed the Pulp Testing Committee with Clark as its secretary. In 1928 he became the first secretary of the Paper Testing Committee of the British Papermakers Association.

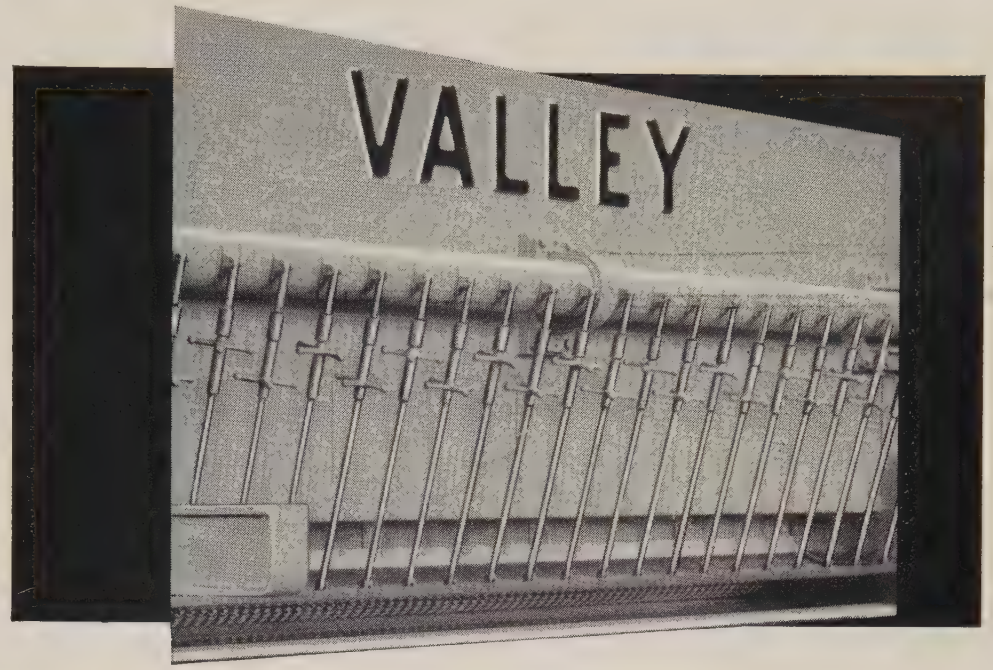
With the assistance of George F. Underhay (who succeeded Clark as technical director of Bowaters) and H. Ainsworth Harrison, he designed the standard British sheet and method. The method of drying the sheets on polished plates was largely due to Macdonald and Cramond of the Inveresk Paper Co., and the disintegrator, to W. M. Bowring of A. E. Reed & Co. This equipment and method ultimately became the official method of the countries of the British Commonwealth and of the U.S.A. Since Bowaters initially purchased 200, and soon after 800, tons of pulp per day, Dr. Clark became vitally interested in pulp qualities—an interest that has continued to grow.

Returning to the United States in 1930 he married Agnes Losee of Duchess Co., N. Y., whom he had met in 1926, and joined the Mead Corp., Chillicothe, Ohio, as research and development engineer. While with Mead he developed the first laboratory kollergang to avoid difficulties with reproducibility inherent in other laboratory beating apparatus, and worked with the late Dr. Harold T. Ruff in building the prototype of the Bauer-McNett classifier. He also helped to develop one of the first "on machine" coating processes.

In 1932, he became technical director of Scott Paper Co., Chester, Pa., where he devised the softness test for paper (now TAPPI Standard T 451 m) and also refined the kollergang method for testing pulp, both of which were instrumental in reducing fluctuations and helping to improve the overall qualities of Scott products.

In 1935 he was promoted to engineering and technical manager of the Scott Paper Co. at Chester, and

the sign of QUALITY



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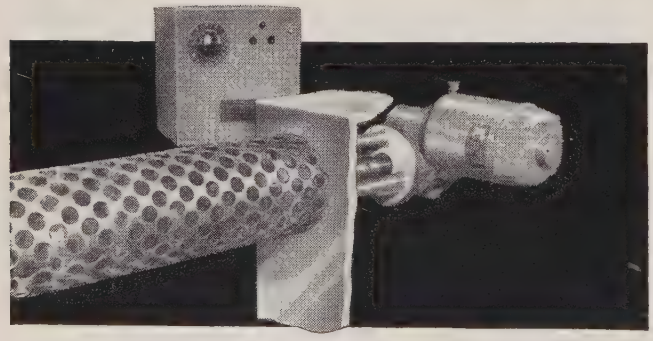

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supervised the rebuilding and modernization, at that time, of all their paper machines and stock preparation systems and the building of their new towel paper machine, the first to make wet-strength paper commercially by the addition of amino-formaldehyde resins. The process was developed (from the original concept and work of K. W. Britt) on a pilot machine and simplified by employing a catalyst that remained alkaline and inoperative until it turned acid and when the paper was heated in the driers. The equipment operated commercially without much change for nearly a decade.

In 1939 he took a leave of absence and went to The Institute of Paper Chemistry, received a Ph.D. degree and became a research associate for a brief period until he was commissioned in the U. S. Army in 1942. At the Institute he worked on fundamental fiber properties, length, specific surface, intrinsic strength, wet flexibility and cohesiveness, and uncovered the important role of the presence and removal of the primary wall to explain the initial rapid increase of strength of pulps with beating. Furthermore, with silvered fibers and electron microscopy he was able to confirm definitely the disputed presence of submicroscopic fibrillae on the surfaces of slightly beaten fibers, as postulated by James Strachan in 1926.

During the next four years, as Major and then Lieutenant Colonel in the Quartermaster Corps and assigned to the QM Subsistence Research Laboratory in Chicago, he wrote or revised the packaging and packing sections of almost all the U. S. Army specifications for foods and rations. He introduced the tiny folding can opener for the U. S. military services, which he redesigned from a larger prototype he had acquired in Vienna, Austria, in 1922. Another innovation was the accessory packages of cigarettes, tissue, etc., packed in the empty spaces between the cans of "C" rations in their shipping cases. He also successfully developed the 30–150–30 lb. asphalt-sandwiched, creped kraft bag liners for shipping cases for foods of which millions were made and successfully used to protect foods against moisture. Because of the high degree of crepe (over 15%) imparted to them the liners remained intact, despite the thinness of the paper, with a substantial saving in the use of the then scarce kraft pulp.

In 1946 he moved to the West Coast as a consulting engineer, and in 1947 he was honored by the Chicago Section of the American Chemical Society by being included in their list of "ten best" in the field of cellulose (*C. & E. News*, Dec. 1, 1947).

In the next ten years, besides continued work on pulp and pulp preparation, he developed a novel air-felting method for making a very uniform sheet of tissue or boards, and for which the basic U. S. patent 2,931,076 has been issued recently. He also invented and holds the basic patent for the manufacture and use of cross-cut fibrous elements (wafers or flakes) from wood for structural boards, and another patent for their use for continuous pulping since the wood fibers are not crushed as with ordinary chipping. In Sandpoint, Idaho, he designed a 50-ton-per-day board mill with many radically new concepts including means for waferizing, storing, metering, felting and pressing, and which made commercial boards within a month of its

*Idea submitted by J. H. Langer, 154 Oswego Lane, Plattsburgh, N. Y.

Photo by Ewing Galloway, N. Y. C.

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"What famous place reminds you of Hamilton Felts? Tell us why in a few words; sign your name and address and name of company. Each month, the idea from a papermaker that we use wins a new 1960 model Shakespeare Spincast Rod and Reel—FREE! When identical winning ideas are submitted by 2 or more papermakers, the one with the earliest postmark will be considered the winner. *Every U.S. papermaker entrant* receives a famous Rex Spoon fishing lure—FREE. Send me your suggestion—today. Ham Feltz, 612 First National Bank Bldg., Cincinnati 2, Ohio."

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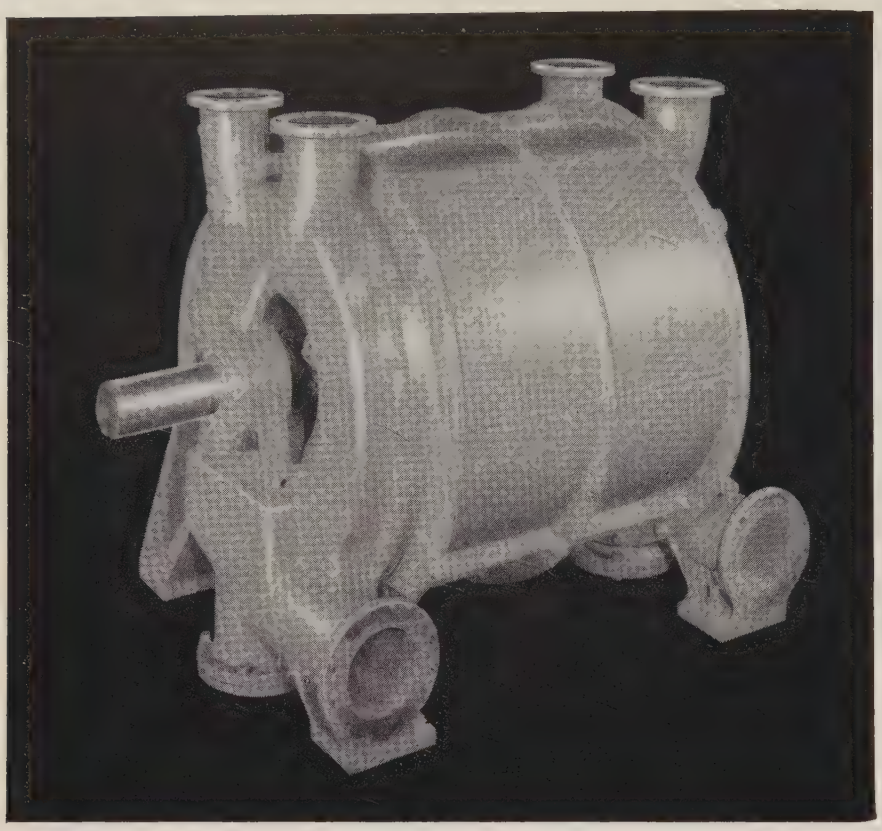
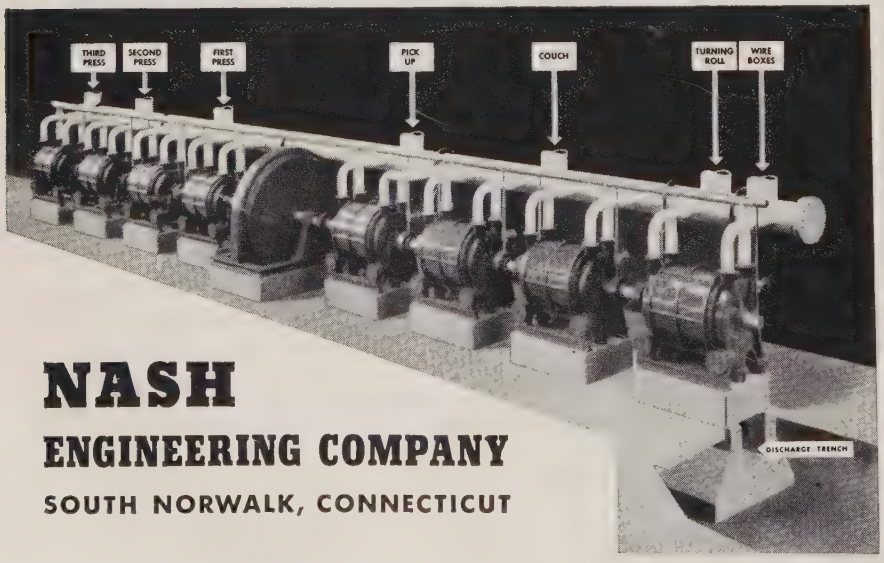


The Nash 5308-A has four separate suction inlets, each of which functions independently of the others. This offers the machine operator great flexibility, since these may be used in any desired combination to produce a variety of capacities and vacuums.

Picture below shows simple drive possible and flexibility of piping permitting capacities to exactly fit requirements of different sections of the paper machine.



NASH
ENGINEERING COMPANY
SOUTH NORWALK, CONNECTICUT

completion. A new 100-ton-per-day board mill, which will employ essentially all the steps and equipment developed at Sandpoint, is now under construction in Saskatchewan, Canada.

A past chairman of the Delaware Valley Section of TAPPI in 1935–36, Dr. Clark subsequently served on many committees in the Association. A member of many of the committees of the Testing Division, he became general chairman of the Division in 1937 and during his seventeen-year term, the number of TAPPI Standard Methods grew from 81 to 200. He also introduced the class of TAPPI Suggested Methods in 1936, and in 1949, the TAPPI Routine Control Methods. He organized the first Testing Conference (Pittsburgh, 1948), and originated the TAPPI Fibrary in 1949. He was a member of the Research Appropriations Committee, 1936–52, member of the Standards Committee, 1937–56, and a member of the TAPPI Executive Committee, 1948–52. He has had the honor, on behalf of the Association, of presenting the TAPPI Medal to B. W. Scribner, W. G. MacNaughton, and R. C. Griffin.

In 1958, after the death of R. C. Griffin, he became chairman of the TAPPI Standards committee, and in 1960, in addition to his consulting work, became professor of pulp and paper science at Oregon State College, where he is conducting further research work on the fundamental properties of paper pulps. He has contributed about 60 technical papers to the literature and also the section on "Properties and Treatment of Pulp for Paper" in "Cellulose and Cellulose Derivatives," Part II of Vol. V of the High Polymer Series, Interscience, New York, 1954.

He has been granted about 45 U. S. patents for inventions which range from a tiny food spoilage indicator to the 3000-ton press working at Sandpoint, which has a 75-sq. ft. rectangular piston. He holds no patents on any test method nor on any piece of pulp or paper testing equipment.

He is a member of the British, Canadian, and Australian Technical Sections and has hobbies of collecting books on pulp and paper, doing research work on testing, metal working in his basement shop, and occasionally fly fishing. At home and at college he is usually trailed by his Scottie dog, Miss McTavish II.

PERSONAL MENTION

New TAPPI Members

Ake E. Backlund, Chemical Engineer, AB Kamyr, Karlstad, Sweden, a 1950 graduate of Technical College of Harnosand.

Marcel Bernhard, Chief Chemist, Société Alsancienne D'Aluminum, Selestat, France. Attended University of Strasbourg.

Ernest T. Bridges, Process Engineer, Ecusta Paper Div., Olin Mathieson Chemical Corp., Pisgah Forest, N. C., a 1959 graduate of University of Alabama.

Ralph Brown, Group Leader, Scott Paper Co., Chester, Pa., a 1958 graduate of Massachusetts Institute of Technology with a Ph.D. degree in 1960 from University of Michigan.

George D. Busha, Process Engineer, Diamond National Corp., Palmer, Mass., a 1959 graduate of University of Massachusetts.

Edward P. Cashman, Head, Wax Products Section, Esso Standard Div., Humble Oil & Refining Co., Bayonne, N. J., a 1941 graduate of St. Peter's College.

Thomas P. Curtin, Chemical Engineer, Riegel Paper Corp., Acme, N. C., a 1959 graduate of North Carolina State College.

Sergio Diena, Maintenance Director, Papelera Mercedes S.A. (Pamer S.A.), Montevideo, Uruguay, a 1955 graduate of Franklin Technical Institute.

Stanley P. Dittmar, Plant Manager, Container Corp. of America, Seattle, Wash., a 1949 graduate of Northwestern University.

Gregg Doll, Partner, Doll Paper Co., Patterson, N. C., a 1947 graduate of Loras College.

Clair M. Donovan, Plant Manager, Wheeler-Van Label Co., Grand Rapids, Mich., a 1942 graduate of Michigan College of Mining & Technology.

Leonard C. Drabant, Project Manager, The Mead Corp., Cincinnati, Ohio, a 1949 graduate of Illinois College.

William C. Drake, Chemical Engineer, Ecusta Paper Div., Olin Mathieson Chemical Corp., Pisgah Forest, N. C., a 1960 graduate of North Carolina State College.

M. W. Dumbeliuk-Czernowicky, Mechanical Engineer, Bank of America, San Francisco, Calif., a 1951 graduate of University of Toronto.

Peter Van Dyke Davies, Project Engineer, Bowaters Engineering & Development, Inc., Calhoun, Tenn., a 1949 graduate of Virginia Military Institute.

Foster G. Ewing, Product Development Engineer, Hinde & Dauch Div., West Virginia Pulp & Paper Co., Sandusky, Ohio, a 1952 graduate of Ohio University.

Carl L. Fishman, Sales Representative, Beloit Iron Works, Beloit, Wis., a 1950 graduate of University of Wisconsin.

Kenneth J. Fletcher, Technical Representative, Hercules Powder Co., Wilmington, Del., a 1953 graduate of Johns Hopkins University.

Dennis Gabor, Sales Engineer, Beloit International Corp. C.A., Zurich, Switzerland, a 1938 graduate of Technical University of Budapest.

Walter Gaylor, Editor, Technical Survey, Lake Hiawatha, N. J., a 1935 graduate of Pennsylvania State University.

Charles W. Glazener, Mill Process Engineer, Ecusta Paper Div., Olin Matheson Chemical Corp., Pisgah Forest, N. C., a 1940 graduate of North Carolina State College.

John L. Goodworth, Sales Service, Corn Products Sales Co., New York, N. Y., a 1946 graduate of University of Pittsburgh.

John Brian Grint, Assistant Mill Superintendent, Bowater-Scott Corp. Ltd., Walthamstow, London, England, graduate of Borough Polytechnic, South West Essex.

Charles B. Hagood, Plant Engineer, International Paper Co., Camden, Ark., a 1934 graduate of Georgia Institute of Technology.

Douglas G. Hall, Mill Chemist, St. Lawrence Corp., East Angus, Que., a 1956 graduate of Bishops University.

Fred A. Haselow, Chief Engineer, Charmin Paper Products Co., Green Bay, Wis., a 1945 graduate of University of Wisconsin.

Lee Roy Herndon, Chemist, North American Rayon Corp., Elizabethton, Tenn., a 1922 graduate of Maryville College.

Charles A. Hodgdon, Salesman, Stein Hall & Co., Inc., New York, N. Y., a 1953 graduate of Colorado State University.

Harry J. Hoffman, Director of Research, Avery Label Div., Avery Adhesive Products, Inc., Monrovia, Calif. Attended Wayne University.

John A. Hoffman, Manager, Quality Systems & Measurements Dept., Kimberly-Clark Corp., Neenah, Wis., a 1941 graduate of Marquette University.

Ernest J. Hurlimann, Mechanical Engineer, Pfeifer and Shultz, Engineers, Minneapolis, Minn., a 1955 graduate of Zurich Technical Institute, Winterthur, Switzerland.

Walter Hurlimann, Consulting Engineer, Muller-Barbieri AG, Zurich, Switzerland, a 1948 graduate of Zurich Technical College.

Hand Junginger, Chief Engineer, Papeteries De France, Grenoble, France, a 1932 graduate of Ecole Superieure Koethen, Germany.

Roy L. Kennedy, Chemist, Georgia Kaolin Co., Dry Branch, Ga., a 1950 graduate of University of Georgia.

Helen E. Laughlin, Librarian, Science & Technology Dept., Los Angeles Public Library, Los Angeles, Calif.

William L. Liike, Junior Engineer, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., a 1955 graduate of State University of Iowa.

Rodney B. Lundy, Vice-President, The William H. Miner Agricultural Research Institute, Chicago, Ill.

Gordon N. Matson, Group Leader, Marathon Div., American Can Co., Menesha, Wis., a 1949 graduate of Northwestern University.

Keith S. McKechnie, Mill Chemist, Premier Paper Mills Ltd., Transvaal, South Africa, a 1957 graduate of Witwatersrand University.

Romano G. Meret, Research Engineer, MacMillan, Bloedel & Powell River Co., Ltd., Vancouver, B. C., a 1947 graduate of University of Padua.

Richard K. Miller, Development Engineer, Union-Bag-Camp Paper Corp., Savannah, Ga., a 1949 graduate of Georgia Institute of Technology.

Kenji Miyazaki, Patent Examiner, Patent Office, Tokyo, Japan, a 1948 graduate of Kanazawa Technical College.

Donald B. Mutton, Acting Manager, Basic Research Div., Industrial Cellulose Research Ltd., Hawkesbury, Ont., a 1949 graduate of University of Toronto with a Ph.D. degree in 1953.

Joseph G. Nagro, Comptroller, The M. W. Kellogg Co., New York, N. Y., a 1929 graduate of New York University, School of Commerce, Accounts & Finance.

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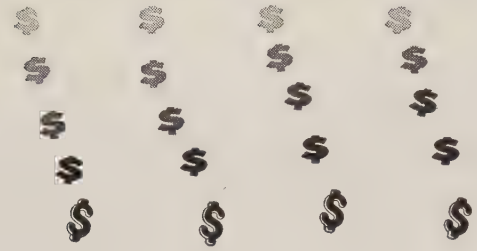

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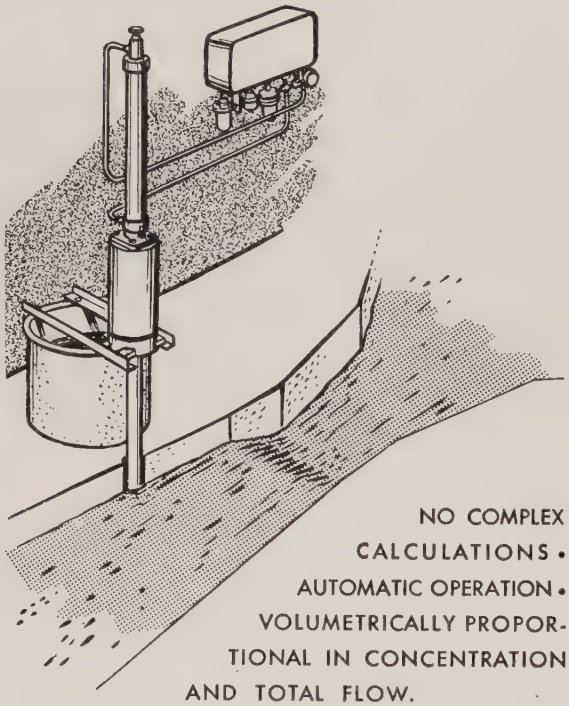

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Robert C. Olson, Senior Process Engineer, Wood Conversion Co., Cloquet, Minn., a 1944 graduate of University of Minnesota.

Paul G. Perra, Senior Research Engineer, Huyck Felt Co., Rensselaer, N. Y., a 1956 graduate of Lowell Technological Institute.

Agnes E. Philos, Librarian, Saskatchewan Research Council, University of Saskatchewan, Saskatoon, Saskatchewan.

Kenneth A. Ploen, Industrial Engineer, Martin Paper Products Ltd., St. Boniface, Man., a 1958 graduate of State University of Iowa.

Howard H. Reynolds, Vice-President, Research & Development, Ludlow Corp., Needham Heights, Mass., a 1936 graduate of Harvard College, with a Sc.D. in 1939 from Massachusetts Institute of Technology.

Antoni J. Rocheleau, Chief Applications Engineer for Paper Industry, Industrial Nucleonics Corp., Columbus, Ohio.

Paul J. Schmitt, Pulp Mill Superintendent, P. H. Glatfelter Co., Spring Grove, Pa., a 1949 graduate of Lehigh University.

George F. Schuning, Jr., New England District Manager, J. O. Ross Engineering Div., Midland-Ross Corp., Boston, Mass., a 1950 graduate of University of Wisconsin.

Rolf S. E. Serenius, Research Engineer, Nekoosa-Edwards Paper Co., Port Edwards, Wis., a 1951 graduate of University of Abo, Akademi, Finland

Heinz Sieger, Production Manager, Hch. Sieger G.m.b.H., Zülpich, Germany, a graduate of University of Munich and University of Bonn, with a Ph.D. degree.

Nils B. Sunden, Leader, Pilot Plant Laminate Section, Skanska Attikfabriken AB, Perstorp, Sweden, a 1955 graduate of University of Lund.

Johanna E. Tallman, Engineering Librarian, Engineering Library, University of California, Los Angeles, Calif.

Kazuaki L. Tatebe, Technical Section, Noda Plywood Mfg. Co., Ltd., Shizuoka-Ken, Japan, a 1957 graduate of University of Tokyo.

Bajaranglal D. Vaid, Sales Engineer, Gannon Dunkerley & Co., Ltd., Bombay, India, a 1950 graduate of Sydenham College.

Clayton C. Wilkie, Vice-President, George S. Armstrong & Co., Inc., New York, N. Y., a 1954 graduate of New York University.

Allen W. Willenbrock, Technical Service Supervisor, Waldron-Hartig Div., Midland-Ross Corp., New Brunswick, N. J., a 1952 graduate of Rutgers University.

John V. Wiseman, Mechanical Engineer, Chas. T. Main, Inc., Boston, Mass., a 1954 graduate of Cornell University.

Appointments

Charles E. Adams is now Assistant Technical Superintendent of the St. Regis Paper Co., Pensacola, Fla.

Alan P. Adrian is now Director of Business Paper Manufacture for the Kimberly-Clark Corp., Neenah, Wis.

Thomas T. Allan is now Assistant Manager of the Industrial Chemical Sales Department of the Virginia Smelting Co., W. Norfolk, Va.

Francis D. Armstrong is now Bleach Plant Superintendent of St. Regis Paper Co., Pensacola, Fla.

Roger L. Barker of the American Cyanamid Co. has been transferred from New York City to Mobile, Ala., as a Technical Sales Representative.

Richard S. Bean, formerly of Scott Paper Co., is now a Staff Engineer for Rust Engineering Co., Birmingham, Ala.

Zane S. Blanchard, formerly of the Portland Co., is now Division Manager of the Portland Overlay Welding Division of Chicago Bridge & Iron Co., Portland, Me.

Robert L. Boehm of the Mead Corp. has been transferred from Chillicothe, Ohio, to Leominster, Mass., as Manager.

Henry G. Booth of the Continental Can Co. has been transferred from Uncasville, Conn., to Augusta, Ga., as Technical Assistant to the Paper Mill Superintendent.

Fritz E. Brauns, formerly of Osaka University, is now a Consulting Chemist at Bellingham, Wash.

Robert M. Brown is now Superintendent of the Aetna Paper Co., Dayton, Ohio.

John G. Casagrande, formerly of E. D. Jones Corp., is now a Field Service Engineer for Huyck Felt Co., Rensselaer, N. Y.

David J. Chen, formerly Student, New York State College of Forestry, is now a Research Chemist for the Dixie Cup Division, American Can Co., Easton, Pa.

Robert H. Coffin, formerly of Cornell Paper Products Co., is now a Chemist for the Thilmany Pulp & Paper Co., Kaukauna, Wis.

Richard G. Cohn is now Pulp Mill Superintendent for St. Regis Paper Co., Pensacola, Fla.

Fred S. Crysler is now Vice-President in charge of paper mills of the Container Corp. of America, Chicago, Ill.

Fred A. Curtis, formerly Vice-President of the American Writing Paper Co., has retired.

George A. Day is now Director of Research of the Brown Co., Berlin, N. H.

G. Allan Dickson, formerly of Arnold, Hoffman & Co., is now a Salesman for the Dexter Chemical Corp., Cambridge, N. Y.

Ronald B. Estridge, formerly a Graduate Student at the Institute of Paper Chemistry is now a Sales Development Engineer for the Albermarle Paper Mfg. Co., Richmond, Va.

Max O. Funk, formerly with Combustion Engineering, Inc., is now Assistant Manager of the American Boiler Makers Association, Newark, N. J.

Rudolph C. Germanson of KVP-Sutherland, Inc., has retired.

Paul M. Goodloe is now Manager of the Chemical Products Division of the Brown Co., Berlin, N. H.

Raymond A. Greene of Monsanto Chemical Co. has been transferred from New York City to Syracuse, N. Y., as a Sales Representative.

Kai K. Halsas, formerly of Enso Gutzeit Oy, is now an Engineer for Sutherland Ltd., London, England.

Charles R. Horch of the Mead Corp. has been transferred from Leominster, Mass., to Chillicothe, Ohio, as General Manager of the Chillicothe Paper Co. Division.

George T. Howe, formerly of Polyplastic United, Inc., is now Chemist for Wyomissing Paper Products, Reading, Pa.

Charles T. Hurley of the Scott Paper Co. has been transferred from Chester, Pa., to Fort Edward, N. Y., as Technical Director.

Raymond L. Jones, formerly of Western Michigan University, is now a Student at the Institute of Paper Chemistry, Appleton, Wis.

Alfred J. Karpinski of the Scott Paper Co. has been transferred from Mobile, Ala., to Chester, Pa., as Production Project Manager.

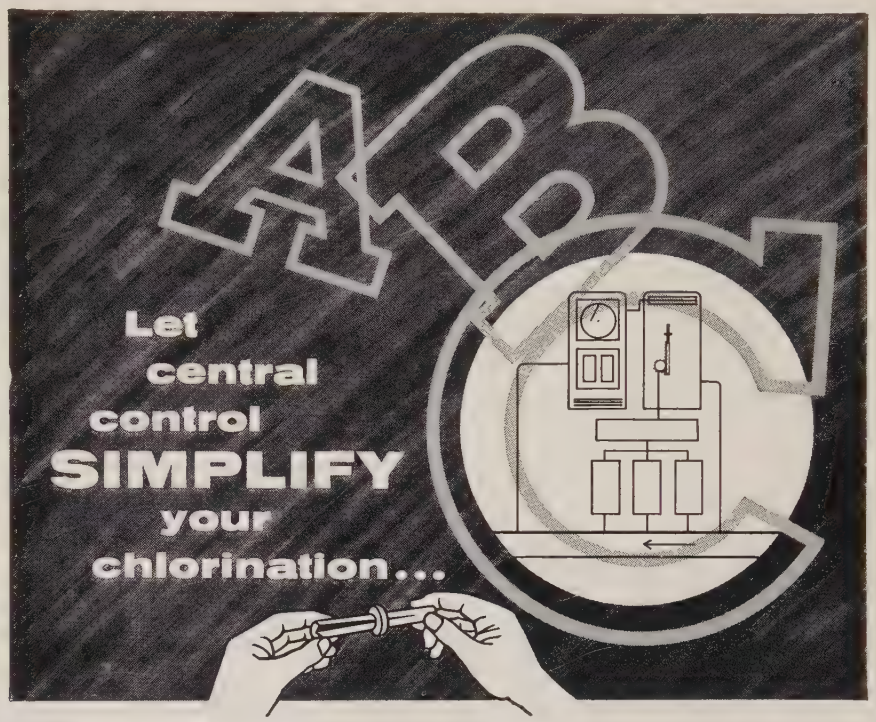
Hans A. Kraessig, formerly of Industrial Cellulose Research Ltd., is now Executive Director of Heberlein & Co. A. G., Scholchenebnet, Switzerland.

Chester G. Landes, formerly Consultant in Charlotte, N. C., is now Assistant Professor of Pulp and Paper Technology, Raleigh, N. C.

Lawrence Leney, formerly of the University of Missouri, is now on the staff of the College of Forestry, University of Washington, Seattle, Wash.

David R. Little is now Superintendent of Coating for the St. Regis Paper Co., Pensacola, Fla.

Olle I. Lundberg, formerly of Procter & Gamble Co., is now Paper Mill Superintendent for Charmin Paper Products Co., Green Bay, Wis.



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WALLACE & TIERNAN INCORPORATED
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E. J. Kidde of Owens Illinois Glass Co. has been transferred from Jacksonville, Fla., to Detroit, Mich., as General Manager of the corrugated box plant.

Samuel E. Martin is now Works Manager for the U. S. Gypsum Co., Galena Park, Tex.

Leslie G. McCowan, formerly of Racquette River Paper Co., is now Productions Assistant to the Manager of Chase Bag Co., Chagrin Falls, Ohio.

Thomas H. McCurry, formerly of Union Bag-Camp Paper Corp., is now Technical Director of the Eastern Box Co., Baltimore, Md.

John J. McDonald is now General Manager of the Pulp-Floc Division of the Brown Co., Boston, Mass.

Alex Morris, formerly of Union Bag-Camp Paper Corp., is now Instruments and Controls Director for the Gulf States Paper Corp., Tuscaloosa, Ala.

Charles A. Morton, formerly of the Kimberly-Clark Corp., is now Vice-President of Alden Press, Inc., Chicago, Ill.

J. Robert O'Grady, formerly of the Carthage Machine Co., is now Assistant to the Vice-President in Charge of Manufacturing, The Upson Co., Lockport, N. Y.

Frederick C. Oppen, formerly of the Marathon Corp., is now a Test Development Specialist for Kimberly-Clark Corp., Neenah, Wis.

Donald Santmeyers of Du Pont Co. has been transferred from St. Louis, Mo., to Houston, Tex.

John H. Schulz, formerly Student at the Institute of Paper Chemistry, is now Assistant Professor of Paper Technology at Western Michigan University, Kalamazoo, Mich.

James J. Shipman is now Vice-President of Kimberly-Clark Corp., Neenah, Wis.

Medie T. Still, Jr., is now Technical Superintendent of the St. Regis Paper Co., Pensacola, Fla.

Howard W. Thompson of Electrical Machinery Mfg. Co. has been transferred from Minneapolis, Minn., to Los Angeles, Calif., as District Manager.

Howard L. Vanderberg, formerly of the Hubinger Co., is now in the sales department of Dexter Chemical Co., New York, N. Y.

George Van Goethem, formerly of American Box Board Co., is now Assistant Pulp Mill Superintendent for Continental Can Co., Augusta, Ga.

Charles E. Varn of the Solvay Process Division has been transferred from New Orleans, La., to New York, N. Y.

Lewis H. White, Jr., is now Paper Mill Superintendent of St. Regis Paper Co., Pensacola, Fla.

Robert M. Whitman, formerly of Riegel Paper Corp., is now a Research Chemist for Continental Diamond Fibre Co., Newark, Del.

G. Ronald Wilmer is now General Superintendent of the Container Plant of Packaging Corp. of America, Grand Rapids, Mich.

Peter N. Yiannos, formerly Student at the Institute of Paper Chemistry, is now a Research Chemist for the Scott Paper Co., Chester, Pa.

* * *

Richard A. Premo has succeeded *R. D. McPheters* as the official corporate representative of the Gould Paper Co., Lyons Falls, N. Y., in TAPPI.

J. J. Schwackler, Manager of the carton and boxboard laboratory, has succeeded *Harry Ford* as the official corporate representative of the Container Corp. of America, Valley Forge, Oaks, Pa., in TAPPI.

J. B. Allan has succeeded *D. H. Bissell* as the official sustaining representative of the Chromium Corp. of America, Waterbury, Conn., in the Technical Association.

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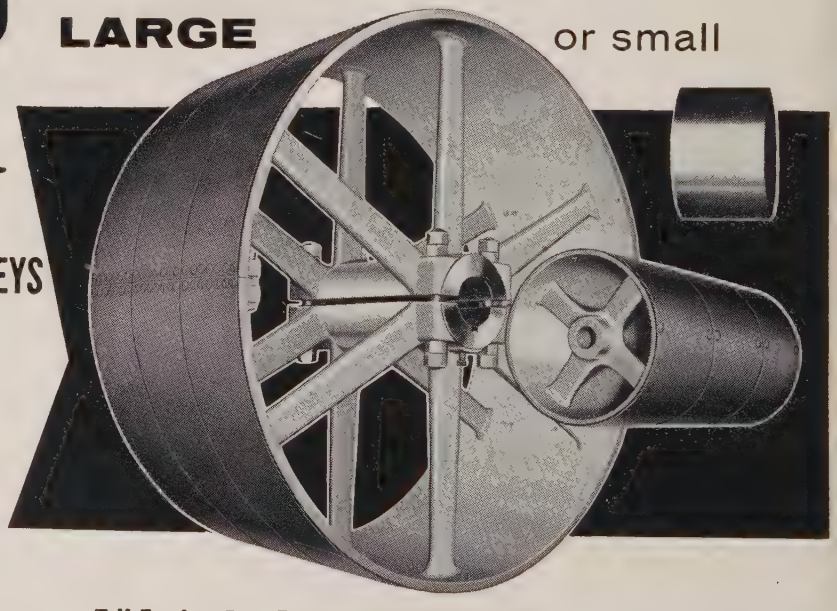
In quality cast-iron pulleys, experience counts and this is what Ehrsam is noted for. Call the J. B. Ehrsam and Sons Manufacturing Company and discuss your needs for standard or special pulleys.



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INDUSTRY NOTES

North American

Statistics

*Paper and Paperboard Production**

Paper and paperboard production for the seven months of 1960 totaled an estimated 20.2 million tons, 3% above the corresponding 1959 total. Paper production increased about one-half million tons or 6%, while paperboard rose by over 100 thousand tons or 1%.

*Pulpwood**

Total receipts of pulpwood for January–June, 1960, were 20,191,000 cords, an increase of 2,142,000 cords over receipts for the comparable period last year. Domestic receipts were 2,072,000 cords above the year earlier total, and imports increased 70,000 cords. All of the regions showed increases ranging from 7% in South Central to 17% in the North Central region.

Pulpwood consumption for January–June, 1960, was 20,380,000 cords, an increase of 1,133,000 cords over the same period of 1959. All of the regions showed increases ranging from 2% in Northeast to 13% in the North Central region.

Inventories of pulpwood at the end of June were 4,975,000 cords, an increase of 21,000 cords above May, 1960, and a 305,000 cords increase above June, 1959. The Northeastern region showed a decrease of 16%. All the other regions showed increases, ranging from 10% in the West to 65% in the South Atlantic.

*Wastepaper and Other Fibrous Materials**

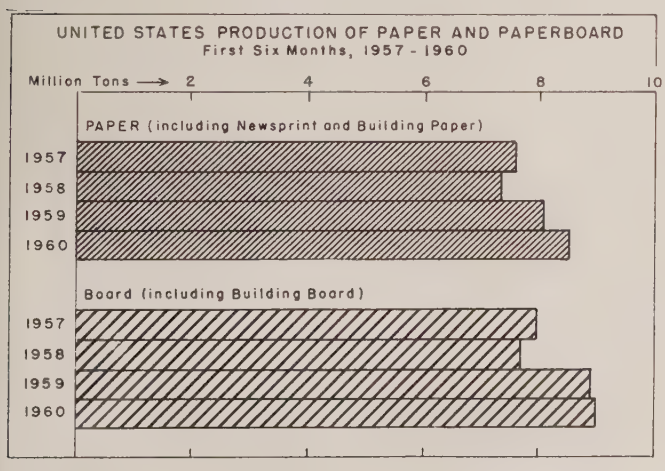
June wastepaper receipts were 781,000 tons; for the first six months of this year they totaled 4,530,000 tons, a decrease of 145,000 tons below receipts for last year.

Wastepaper consumption for June was 782,000 tons; the January–June total was 4,578,000 tons, a decrease of 40,000 tons from consumption for the same period last year.

Inventories at the end of June were 539,000 tons, 1000 tons below May and an increase of 47,000 tons above inventories at the end of June, 1959.

Consumption of total fibrous materials for June was 869,000 tons; the January–June total was 5,082,000 tons, 71,000 tons below consumption for the comparable period last year.

* American Paper and Pulp Assoc., *Monthly Statistical Summary* 38, No. 9 (September, 1960).



Inventories of total fibrous materials at the end of June were 911,000 tons, 29,000 tons below May and 41,000 tons above inventories at the end of June, 1959.

*Wood Pulp**

Production of wood pulp for January–June, 1960, was 12,726,000 tons, an increase of 678,000 tons above the comparable 1959 total.

Wood pulp consumption in the manufacture of paper and board for January–June, 1960, was 13,058,000 tons, an increase of 593,000 tons above consumption for the same period last year.

Imports of wood pulp for January–June, 1960, were 1,123,282 tons, 7% below imports for last year. Imports from Canada for January–June, 1960, were 1,007,451 tons, an increase of 1% above the comparable period of 1959. Overseas imports for January–June, 1960, were 168,005 tons as compared to 214,007 tons for the same period last year.

Exports of wood pulp for January–June, 1960, were 549,482 tons, as against 289,581 tons exported during the same period last year.

Inventories of wood pulp at paper and board mills at the end of June were 535,491 tons, an increase of 9000 tons above inventories at the end of May and 11,000 tons below inventories at the end of June, 1959.

January–August Production at Annual Rate of 34.7 Million Tons

Estimates compiled by the American Paper and Pulp Association indicates that paper and board production for the first eight months of this year totaled 23.1 million tons, indicating an annual production rate of 34.7 million tons. Total eight months' production was 2½% above the comparable period last year; paper production was 10.3 million tons, up 5%; paperboard production was 10.7 million tons, up 1% while construction paper and board was 2.1 million tons, a decline of 3%.

Chicago

Site of 1961 Plant Maintenance & Engineering Show

Chicago will be the site of the Twelfth Annual Plant Maintenance & Engineering Show. The show will run for four days, from Jan. 23 through 26, 1961, at the International Amphitheatre. The conference will run for three days, January 23 through 25. Morning sessions of the conference will take place at the Amphitheatre and evening sessions at the Palmer House. The events have been staged in Chicago only three times in the past—in 1954, 1955, and 1958. The 1961 exhibit area is expected to exceed six acres and about 375 companies are expected to participate as exhibitors.

The theme for the 1961 show will be "The Maintenance Operation Meets the Needs of Increased Production."

Visitors who wish to receive advance rapid registration cards, hotel or conference information should write Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y.

Louisville

Forest Products Research Society Convention

The Forest Products Research Society will hold its 1961 Annual Convention in Louisville, Ky., June 18–22, 1961. Headquarters for the Convention will be the Kentucky Hotel.

Chemical Pulping Processes

Chemipulp and Chemipulp-KC systems help achieve maximum production of uniform, high quality pulp at lower cost and provide means for efficient recovery of heat and chemicals.

- Hot Acid Systems
- Jet-Type Sulphur Burners
- Independent Recovery Systems
- Spray-Type SO_2 Gas Cooling Systems
- Recovery Towers
- Sulphite Acid Systems
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SCORING KNIVES and SEGMENTS
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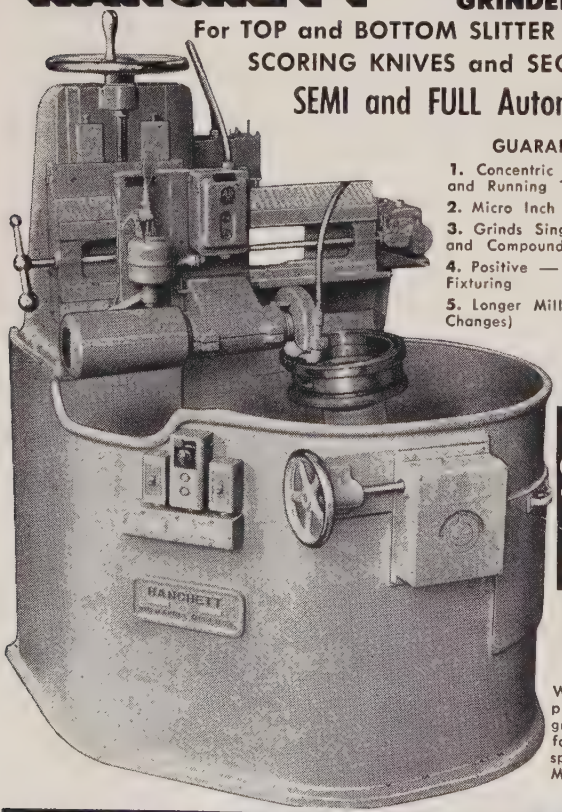

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The Society, numbering approximately 4000 members, was founded in 1947. It serves as the technical society for the wood industry and has as its primary purpose to encourage and promote the fullest and most efficient use of wood and other forest products.

The 1961 Convention is under the auspices of the Ohio Valley Section. Carl Trinkle of the Baldwin Piano Co., Cincinnati, Ohio, is the general chairman.

Overseas

New U. S. Pulp and Paper Markets

At the request of the Bureau of Foreign Commerce as part of the Department of Commerce's Export Expansion Program, the U. S. Foreign Service has reported the following pulp and paper products as good market prospects:

Australia: Packaging materials, including papers, boards, and boxboards.

Burma: Old newspapers.

Chile: Cellulose, mechanical pulp.

Columbia: Newsprint.

Ecuador: Kraft paper.

Kenya: Stationery.

Korea: Pulp, mainly chemical; paper, especially newsprint, woodfree, kraft, and cigarette.

Kuwait: Stationery, paper products.

Italy: Stationery.

Mexico: Newsprint and specialty papers.

Morocco: Paper pulp.

New Zealand: Vegetable parchment and greaseproof paper.

Pakistan: Insulating materials.

Rhodesia: Paper, for printing and writing.

Sudan: Paper products.

Switzerland: Paper towels, packaging materials, masking tape, office supplies.

Turkey: Kraft paper (*Foreign Commerce Weekly, 9/5/60*).

Western Europe

Paper and Board Demand by 1965 Estimated at 22 Million Metric Tons

According to a report recently issued by the Organization for European Economic Cooperation, revised estimates indicate paper and board consumption in 1965 at 22 million metric tons. By comparison the 17 Group OEEC countries, and Finland consumed 15.6 million tons in 1958 and 16.7 million tons in 1959.

Note: Copies of this report, "Pulp and Paper—Statistics 1959; Trend 1960," are available from the OEEC Mission, Publications Office (Suite 1223), 1346 Connecticut Avenue, N. W., Washington 6, D. C., for $1.00.

Belgium

Anciens Etablissements Louis De Naeyer S.A.

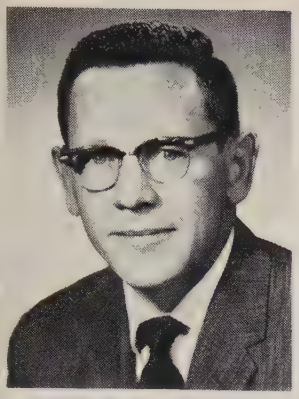
The company celebrated its centenary on September 16 and 17 when the Minister of Economics inaugurated the new plants that went into service on Friday, September 16.

These plants include a sixth paper machine specially designed for the manufacture of wrapping papers of high grade quality such as Cristal (glassine), thin papers for coating and laminating purposes, etc.; a 20-roll supercalender for glassine, working on the full width of the paper machine; and several other finishing machines.

Finland

Big Paper Machine Contract

A contract has been signed recently between Oy Wilh. Schauman Ab and Valmet Ab according to which Valmet is to deliver a paper machine for a new kraft paper mill to be built in Pietarsaari, Finland.



Robert M. Brown, Aetna Paper Co.

The paper machine, to be equipped with a differential drive, a 7150-mm. wire width, constructional speed 75–750 m. per min., is designed mainly for 70–80 g. per sq. m. and an annual production volume of approximately 80,000 tons. The machine will be built at the Rautpohja Works in Jyväskylä, and this factory of the Valmet-concern will also supply the slitter rewinder as well as packaging machines for paper rolls. In addition, an air-conditioning and heat-recovering equipment of Valmet design will be also delivered. On the whole, this contract is the largest so far entrusted to a manufacturer in Finland by the Finnish paper industry.

The production of this new mill is intended entirely for the export market. With the completion of the plant in 1962, the production of kraft paper in Finland will rise by 25%.

Paper Manufacturers and Converters

Aetna Paper Co.

Appointment

Robert M. Brown has been appointed superintendent of Aetna, Division of Howard Paper Mills, Inc., in Dayton. He replaces W. Clare Monaghan, who served as superintendent for six years until his death, June 30.

Ashuelot Paper Co.

New Appleton Rewinder Installed

A 100-in. (Model 65) Appleton rewinder was installed at Ashuelot's Hinsdale mill late in September.

Designed for handling winding tissue the new winder is powered by a 20-hp. single motor drive (Reliance). Rolls up to 60-in. in diam. will be wound and slit at speeds up to 2000 f.p.m.

Brown Co.

Changes in Bermico Division

Executive administration changes in the Bermico Division of the Brown Co. have been announced by vice-president Malcolm T. Murray, general manager of the division, which manufactures the Bermico line of electrical conduit and sewer pipe.

Mr. Murray, who is responsible for all production and distribution at Berlin, N. H., and other Bermico plants, listed Robert E. Cross as sales manager for the entire division. Production and operations at each of the Bermico plants will be under the control of a plant manager who will report directly to Mr. Murray.

Robert W. Thayer is the plant manager at the Berlin, N. H., operation; he will be assisted by David H. Crockett, newly appointed as operation superintendent.

Bernard M. Guthrie is in charge of the Oregon facility at Corvallis, and is assisted by Norman H. Desart, as operation superintendent.

Vice-President Robert W. Andrews, formerly located in Berlin, is directing activities at the company's new plant in Birmingham, Ala. Donald Welch, formerly located at the Berlin facility, will serve as operating superintendent at the Birmingham plant.

The Hamilton, Ont., plant, scheduled to go into production this month, is operated by a separate Canadian corporation

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CLARK TOUGHNESS TEST

Measures Absorption of Energy at High Speed Rupture.

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Correlates well with drop test.

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ELMENDORF TEARING TESTER serves double duty as a tear tester and a toughness tester.

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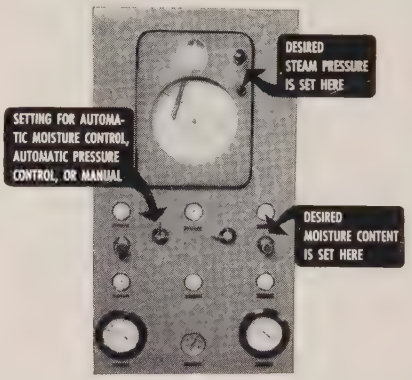
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Holds Moisture Content within ½ of 1%

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known as Bermico Products, Ltd. Edward G. Spencer, will supervise its operations.

Columbia Cellulose Co., Ltd.

Research Establishment for Prince Rupert

Columbia will build new research facilities adjacent to its Prince Rupert pulp mill, according to an announcement by T. N. Beaupré, president. Completion is scheduled for June, 1961.

The Prince Rupert mill produces sulfite acetate and viscose pulps for manufacture into textiles, chemicals, and plastics; it also produces specialty paper pulps.

Together with its subsidiary, Celgar Ltd., the company will soon be able to offer a full range of chemical pulps including bleached kraft paper pulp. The Celgar Kraft mill, near Castlegar, B. C., is scheduled for production in December of this year.

Crown Zellerbach Corp.

Appointment

Gus Ostensen, resident manager of C. Z.'s Antioch, Calif., mill division since 1955, has been appointed production manager of Crown Zellerbach Corp. International. John M. Miller, who has been assistant resident manager since January, 1959, succeeds Mr. Ostensen.

Crown Zellerbach International was established in 1959, with G. J. Ticoulat as president.

Hamilton Paper Co.

125-In. Appleton Rewinder Installed

Hamilton has scheduled installation of a new Appleton rewinder at its Plainwell, Mich., mill for late November.

Dirven by two 40-hp. motors (G.E.) the rewinder will operate at speeds up to 3000 f.p.m. Fifty-inch diameter rolls of various bond grades will be wound and slit (gang type shear slitters) on $13^1/_2$-in. drums.

Hammermill Paper Co.

Union Assets Purchased

Agreement has been reached for purchase by Hammermill of the business of Union Envelope Co. of Richmond, Va. No change is comtemplated in the personnel of Union or in its operating and marketing policies.

Keyes Fibre Co.

Pulp Molding Plant on West Coast

Keyes Fibre Co. of Waterville, world's largest maker of molded pulp products, has announced plans for a new manufacturing plant in Sacramento, Calif., where the company has taken an option on a manufacturing site of approximately 30 acres. Anticipated cost was not announced pending the completion of engineering and architectural plans and cost estimates.

The plant will be of rectangular, partial two-story design with 150,000 sq. ft. of ground area offering 254,000 sq. ft. or 5,000,000 cubic feet of manufacturing, storage, and office space. It will employ approximately 200 people with an initial yearly payroll of nearly $1,000,000. About 90% of its employees will be recruited and trained in the Sacramento area.

Kimberly-Clark Corp.

J. J. Shipman V. P.

James J. Shipman has been elected a vice-president of K.-C. Formerly director of research, Mr. Shipman will continue to head the company's research operations.

KVP Sutherland Paper Co.

Laboratory Appointments

Two new laboratory appointments were recently made within the technical department of the KVP Division, Kalamazoo, Mich.

David L. Brew and James J. Matousek were appointed research engineers.

R. C. Germanson Retires

Rudolph C. Germanson retired on August 31 from the KVP Division of the KVP Sutherland Paper Co. after many years of service to the paper industry.

The Mead Corp.

Directors Approve the Purchase of Assets of Gilbert Paper

Mead Board of Directors has approved an agreement to purchase the assets of the Gilbert Paper Co., Menasha, Wis., subject to the approval of Gilbert Stockholders.

The Gilbert Paper Co. under the leadership of T. M. Gilbert, president and general manager since 1954, has an outstanding reputation for the production of cotton fiber (rag content) papers.

Nekoosa-Edwards Paper Co.

186-In. Appleton Winder Instailed

A 186-in. Appleton winder was installed on the new no. 2 machine at the Nekoosa mill in August.

Designed to operate at speeds up to 5000 f.p.m. the winder is equipped with two 100-hp. motors (Louis Allis) and a 100-hp. drag generator for maintaining constant tension. It will be used on grades and will wind and slit 60-in. diam. rolls on 21-in. drums.

Auxiliary equipment includes a 16-in. diam. rider roll, pneumatically operated score-cut slitters, a shaft puller, and a combination weighing and lowering table.

Strauss Joins Research Department

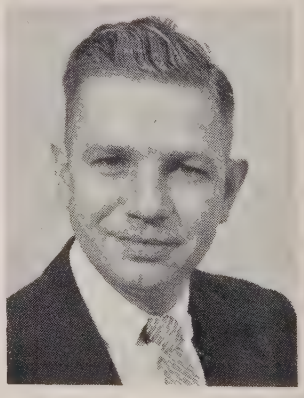
Roger W. Strauss, a former faculty member of the New York State College of Forestry, Syracuse, N. Y., has joined the research department of Nekoosa-Edwards Paper Co. as a section leader for chemical and physical research.

New Haven Board & Carton Co.

Appointment

James J. Harrison has joined the company as vice-president in charge of manufacturing, with headquarters in New Haven, Conn. His responsibilities will include all manufacturing plants: New Haven Division, New Haven, Conn.; Bartgis Division, Ilchester, Md., and Fitzhugh Corrugated, Lakeview, Long Island, N. Y.

Rudolph C. Germanson, KVP Sutherland



Roger W. Strauss, Nekoosa- Edwards

Marathon Southern Corp.

Domed Cover Solves Broke Chest Corrosion

To combat corrosion in a 25-ft. diam. broke chest cover, Marathon has installed a fiberglass-reinforced polyester cover, at its Nahoola, Ala., mill. When loads are exerted on

Finished Kabe-O-Rap cover is shown here as Rust Engineering Co. workmen prepare to lift it to top of Marathon Southern's tile broke chest

the cover, stainless steel cable provides extra reinforcement to hold the polyester laminate in compression, thus taking full advantage of the strongest physical property of the laminates. The Kabe-O-Rap cover was designed and built by Metal-Cladding, Inc., North Tonawanda, N. Y.

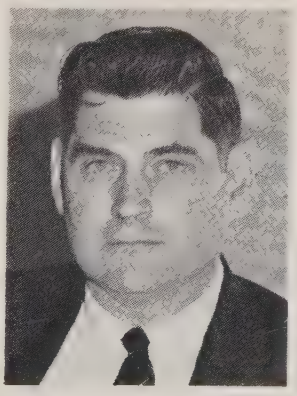
The polyester is Hetron (R)92, a fire-retardant corrosion-resistant resin produced by the Durez Plastics Division of Hooker Chemical Corp., North Tonawanda, N. Y.

Penobscot Chemical Fibre Co.

Manager of Services Appointed

Raymond P. McGinley has been appointed manager of services of the company's mills in Old Town, Me.

Mr. McGinley is a graduate of the University of Maine, receiving his Bachelor of Science degree in Pulp and Paper in 1938. He is a member of TAPPI and also a member of the Steam and Power Committee in National TAPPI.



Raymond P. McGinley, Penobscot Chemical Fibre Co.

Rome Kraft Co.

New Waste Treatment System

The company is constructing a new waste treatment system in Rome, Ga., to reduce the quantity of waste materials discharged into the Coosa River.

Construction of additional pulp and papermaking equipment and power services to increase the mill's capacity for making containerboard has been under way since May, 1959.

Rome Kraft Co. is jointly owned by Inland Container Corp. of Indianapolis, Ind., and The Mead Corp. of Dayton, Ohio.

Weyerhaeuser Co.

Shipping Container Plant for Olympia

Weyerhaeuser is to build a new shipping container plant near Olympia, Wash. Scheduled for completion early in 1961, the plant will employ about 100 persons. Paperboard will be provided by Weyerhaeuser mills at Longview, Wash., and Springfield, Ore.

Weyerhaeuser has operated a similar plant at Yakima, Wash., since 1952. Other container plants are located in 16 states.

High Quality Mg-Base Pulps

The company is making changes to its pulp mill at Grays Harbor, Wash., to enable the production of additional grades of high quality, bleached sulfite pulps produced using a two-stage magnesium-base cooking process, for which patent application has been made. As a part of this development the company is also installing additional chlorine dioxide bleaching facilities.

Educational Institutions

University of Maine

Louis Calder Foundation Grant

A gift of $30,000 from the Louis Calder Foundation has been made to the University of Maine. Twenty-thousand dollars of this gift will be used for a scholarship program over an 8-year period and the balance for the support of the teaching of chemical engineering, particularly pulp and paper technology.

Under the plan twenty $1000 scholarships will be awarded during the next eight college years beginning in 1961.

First preference for these awards will be given to students living in the Kennebec watershed, which includes towns along or near the Kennebec River. Preference will also be given to students whose major interest is pulp and paper technology or chemical engineering and who indicate a desire to enter the papermaking field.

The $10,000 to be used to support teaching will be turned over to the University of Maine Pulp and Paper Foundation as a newly established fund. The income from the fund will be available for aid to teaching and the principal may be used for the same purpose if and as foundation trustees see fit.

Louis Calder, who established The Louis Calder Foundation and who is a native of New York City, has been active in the pulp and paper business for more than 60 years as the head of Perkins-Goodwin Co. His son Louis Calder, Jr., is vice-president of the company and a trustee of the Calder Foundation.

Industry Suppliers

American Cyanamid Co.

Chemicals Plant for Vancouver

A plant to produce chemicals, primarily for the paper industry of the area, is to be built by the company in Vancouver, Wash. The new plant is to be located on a 12-acre site, north of N. E. 78th St. and adjacent to the rail lines to Yacolt.

Appleton Machine Co.

Mater Division of Appleton

On September 1, The Mater Machine Works, Inc., Corvallis, Ore., manufacturers of packaged and automated sawmills became a division of the Appleton Machine Co., 77-year-old makers of pulp mill and paper machinery of Appleton, Wis.

According to Tany Agronin, president of Appleton, the purchase involved Mater company's manufacturing, sales, and engineering, but no machinery or real estate in Corvallis.

Milton H. Mater (left) and Tany Agronin sign papers which consummated purchase of Mater Machine Works, Inc., by Appleton Machine Co., Appleton, Wis.

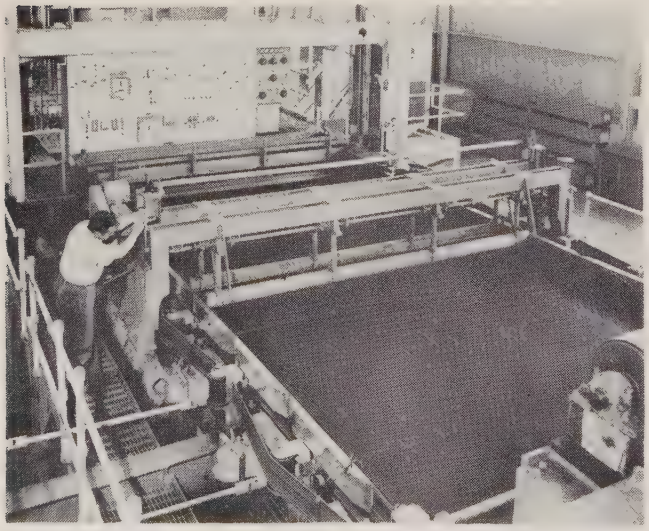
Sales and engineering will be continued at Corvallis, which will be known as the Mater division of Appleton, with Milton H. Mater, who was president of Mater Machine Works, as vice-president in charge. Mater Engineering, a separate company, also was acquired and will be operated by Appleton.

Mater's famed sawmill machinery will be manufactured at the big plant at Appleton. Mater Machine Works has been national and international in scope and recently installed mills for Union Carbide at Charleston, W. Va.; Cascades Plywood Corp., Reedsport, Ore.; Placerville Lumber Co., Placerville, Calif.; and the Mayo Lumber Co., Naniamo, B. C.

Betz Laboratories, Inc.

Chlorine and Nonoxidizing Biocides

Betz has made available a new Water Conditioning Data Sheet entitled, "Slime Control with Chlorine and Non-Oxidizing Biocides." It shows how the judicious use of chlorine and the supplemental use of other biocides will extend cooling tower life. Copies are available from Betz Laboratories, Inc., Gillingham & Worth Sts., Philadelphia 24, Pa.



The 160-in. Black-Clawson fourdrinier board machine at The Celotex Corp.'s new L'Anse, Mich., plant

The Black-Clawson Co.

Equipment for New Celotex Mill

Two divisions of The Black-Clawson Co. manufactured essential equipment for the new insulating fiberboard mill which The Celotex Corp. officially opened September 24 at L'Anse, Mich. One of the principal pieces of production machinery is the six-acre plant is the 160-in. wide fourdrinier board forming machine built by Black-Clawson's paper machine division. The stock preparation system ahead of the machine includes a Hydrapulper, consistency regulator, agitators, and pumps supplied by the Shartle Division of B-C.

With a daily capacity of 500,000 sq. ft. of $^1/_2$-in. fiberboard, the L'Anse plant increases Celotex fiberboard production capacity about 25%. Celotex converts the board into such products as acoustical and decorative ceiling tile, insulating sheathing, insulating roof deck, and roof insulation. The output of the L'Anse mill will be distributed principally in ten north central states.

Consolidated Water Power & Paper Co.

Multimillion Dollar Expansion

A new paper machine to produce 25,000 tons of enamel printing papers annually will be installed at Consolidated's Wisconsin River Division. Startup is expected to be September 1961.

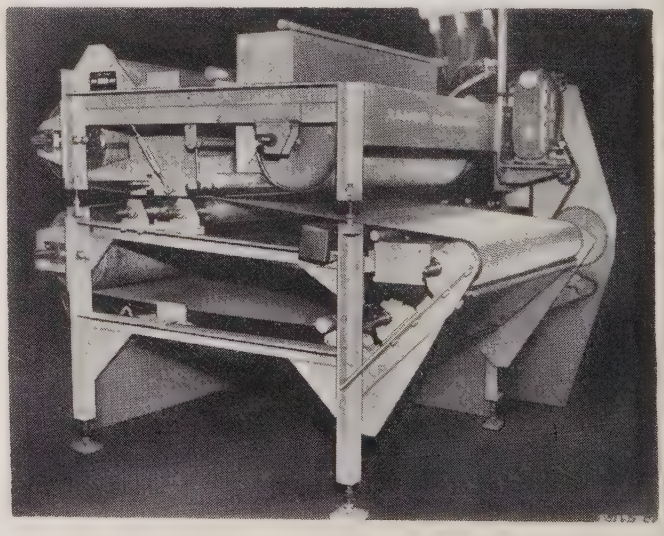
According to Stanton W. Mead, president of the company, estimated cost of the entire project which includes expansion of auxiliary facilities is $8,000,000, Mead stated. To be enlarged are Wisconsin River Division's boilerhouse, groundwood pulp and bleach departments, coating plant, finishing facilities, and stores. Chemical pulp requirements will be met by the company's other plants.

Curlator Corp.

New Type Saturator

A new type saturator, called the Rando-Bonder, offering numerous advantages in the manufacture of nonwovens, felts, specialty papers and specialty fabrics, has been jointly developed by Curlator Corp., East Rochester, N. Y., and Celanese Fibers Co., a division of Celanese Corp. of America.

The new saturator is claimed to enable the rapid, uniform saturation of nonwoven webs, without drafting or distortion, and provides flexibility and ease of operation not encountered in existing equipment. The versatility of the machine is demonstrated in its processing of many materials with uniform penetration and controlled pickup are required



Curlator Corp.—Rando-Bonder

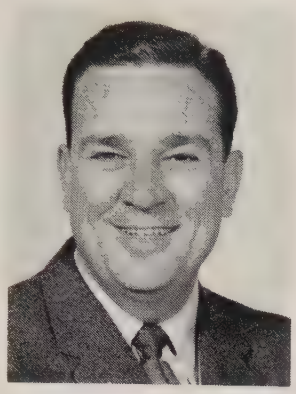
without distorting the base web. Structures of natural, synthetic, mineral, metal, reclaimed tire cord, shoddy, plastic scrap, felt, woven and nonwoven materials may be successfully processed.

Outstanding features of the Rando-Bonder are: (1) horizontal treatment of fibers minimizing distortion of uniform fiber lay.

E. I. du Pont de Nemours & Co.

Appointment

Harold L. Sager has been appointed assistant manager of the New England district sales office of the du Pont Dyes and Chemicals Division. Mr. Sager has been with du Pont in dyes and chemicals sales work since 1939.



Harold L. Sager, E. I. du Pont de Nemours & Co.

General Electric

Manual Motor Starters

Bulletin GEA-6358C describes G.E.'s CR101 manual motor starter for fractional-horsepower motors and CR-1062 manual motor starter for integral horsepower motors up to $7^1/_2$ hp.

Divided into two sections, the publication includes photos with call-outs explaining construction features of both units. Outline diagrams show dimensions. Heater selection tables and prices for both types are also included.

Bulletin GEA–6358C may be obtained from the General Electric Co., Schenectady 5, N. Y.

Hooker Chemical Corp.

Appointments

F. Leonard Bryant, a vice-president of Hooker since 1957, was elected executive vice-president and a director of the corporation.

Also elected directors are Thomas F. Williams, a Hooker vice-president, and Werner P. Gullander, executive vice-president and a director of General Dynamics Corp. Both have been named also to the executive committee of the board of directors.

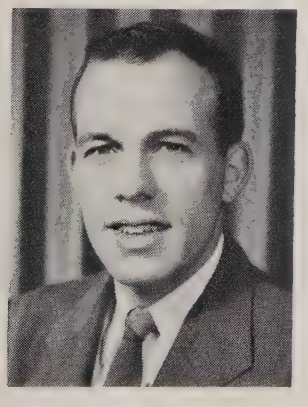
Mr. Gullander will fill the vacancy created by the resignation of E. Lewis Burnham, a Hooker director since 1924.

Huyck Felt Co./Division of Huyck Corp.

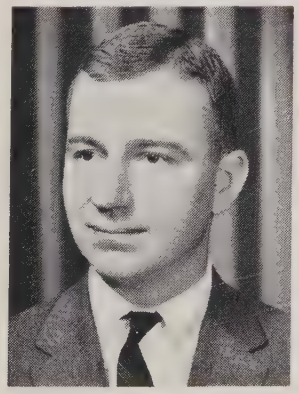
Promotion

John E. Wilbur has been promoted to assistant manager of field service engineering. During his more than ten-year association with the paper industry, he was employed by S. D. Warren Co. and Carton de Columbia, a subsidiary of the Container Corp. of America.

John G. Casagrande succeeds Mr. Wilbur as Huyck field service engineer for portions of New Jersey, Pennsylvania, Maryland, Delaware and North Carolina. Mr. Casagrande is a graduate of the pulp and paper school at Syracuse University and has worked in the paper industry since 1951.



John Wilbur, Huyck Felt Co.



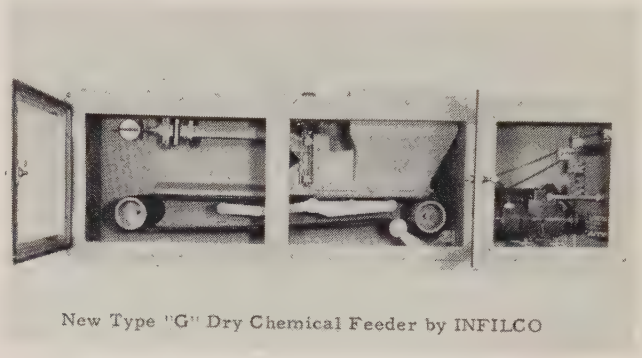
John Casagrande, Huyck Felt Co.

Infilco, Inc.

New Type "G" Dry Chemical Feeder

The mechanism and operating principles of the new type "G" Gravimetric chemical feeder are discussed in Bulletin 260 issued by Infilco, Inc.

The type "G" feeder handles all dry chemicals normally used in water and waste treatment, whether these are in powder, granule or lump form up to $^3/_8$-in. in diameter. Its weighing mechanism gives an accuracy of $\pm 1\%$ of the set rate over an operating range of 20:1, and the entire "G" feeder is housed in a dusttight enclosure.



New type "G" dry chemical feeder by Infilco

Request Bulletin 260 from Infilco, Inc., Tucson, Ariz.

I-T-E Circuit Breaker Co.

Mobile Exhibit of 4160-v. Switchgear on "Door-to-Door" National Tour

A 44-ft. mobile unit will give practical, on-the-spot demonstrations on the recently introduced 4160-v. switchgear equipment to hundreds of customers and prospects across the nation. The trailer is going directly to electric utilities' industrial plants, and contractors' and consulting engineers,

Renovated interior of I-T-E trailer shows metal-clad switchboard and disassembled circuit breaker on right. Back-lighted shadow box on wall gives excellent view of new features which visitors can study in air-conditioned comfort

offices where groups of from 5 to 15 persons are expected to attend 2-hr. sessions at each location. The meetings will consist of the showing of an 18-min. sound film, a complete demonstration of the equipment and a question-and-answer period.

The redesign of the metal-clad equipment incorporates such features as compact design, closed-door, horizontal drawout, stored-energy closing, a new concept of arc extinction known as the ironless blowout coil, maximum safety and one-man maintenance.

Kinetic Dispersion Corp.

Model T-20 Kady Mill with Heat Exchanger

KDC announces the introduction of its new T-20 top-driven Kady mill with built-in heat exchanger. This mill is driven by either a 25-hp., two speed, or 30-hp. single-speed motor at 6500 r.p.m. All working parts, including the heat exchanger, are stainless steel. The unit is designed to work in tanks with capacity up to 100 gal. Featured is the exclusive new Kady-design heat exchanger which permits full cooling of the batch in any standard nonjacketed tank.

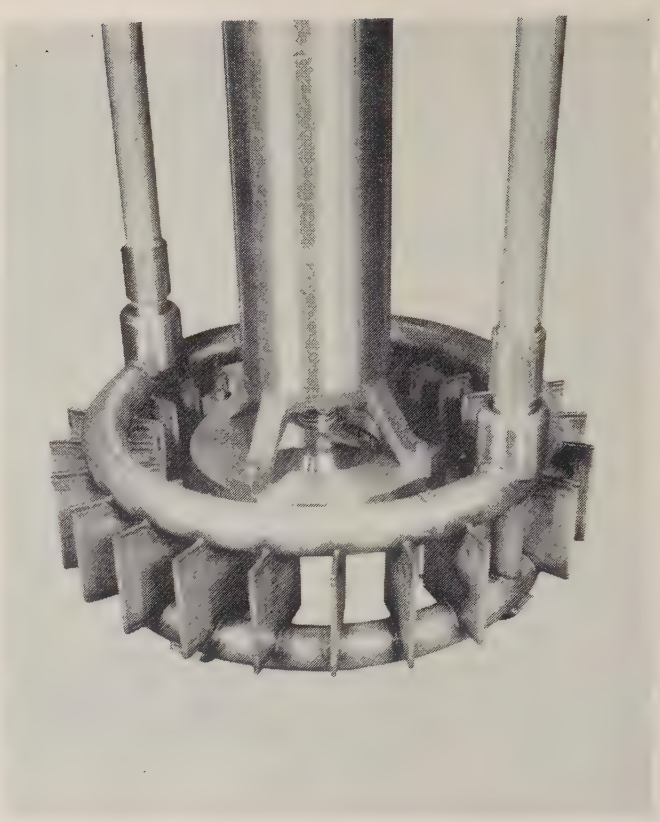
Heat Exchanger

KDC also announces the introduction of its new high efficiency heat exchanger system for use in heat transfer problems where high rates of heat transfer are needed in conjunction with agitation.

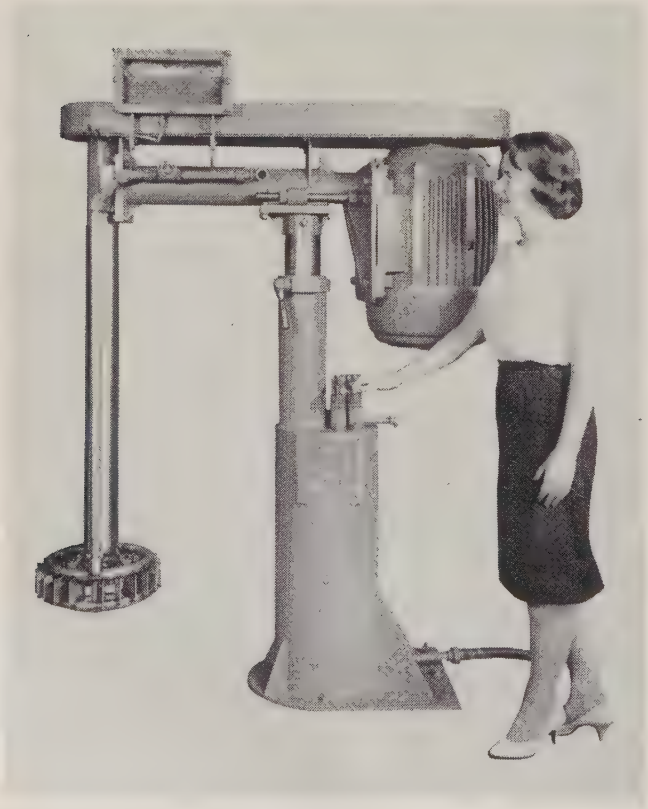
This unit is now offered in four standard sizes and can be built on specification for use in any type of tank and chemical operation. Pictured is application of the heat exchanger on the head of a 30-hp. Kady mill where the exchanger is used as a cooling medium. This unit can also be used in conjunction with the complete line of Kadyzolvers offered by the company.

Model 600B, 1000-Gal. Kady Mill

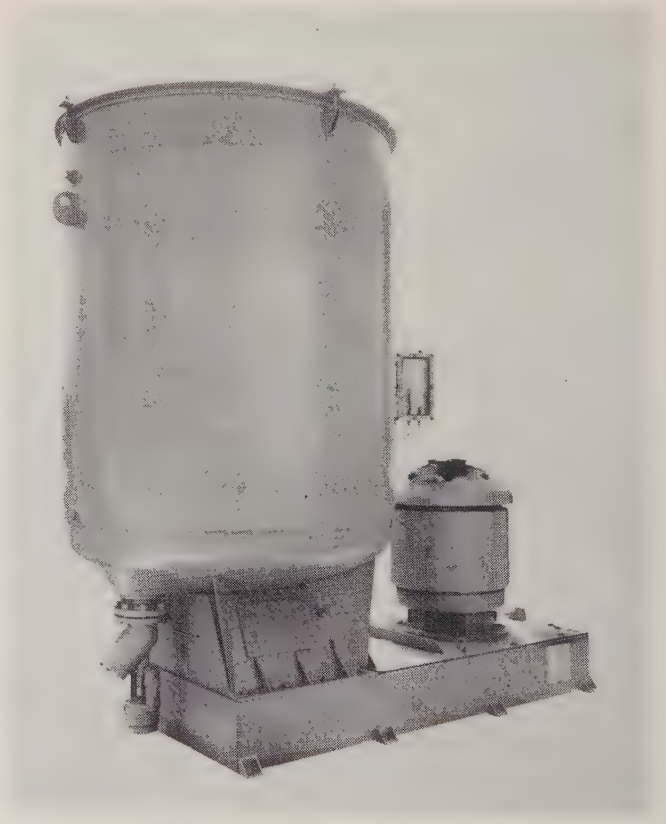
The 600B, 150-hp., 1000-gal. capacity, high-speed dispersion mill is now available. It will handle all types of solids in liquids and liquid-in-liquid mixtures where ultrafine dispersion is necessary or ultrafine homogenization is required, in batches up to 800 gal. Pigment charges such as titanium or paper-coating clays can be handled up to 8000 lb. dry weight per charge. Dispersion cycles will run normally from 30 min. to 1 hr. The mill features all stainless steel



Heat exchanger, Kinetic Dispersion Corp.



Model T-20 Kady mill with heat exchanger, Kinetic Dispersion Corp.



Model 600B 1000-gal. capacity Kady Mill, Kinetic Dispersion Corp.

construction, air-operated, 5-in. valve, built-in heat exchange, plus tank jacketing for rapid cooling or for use in rapid heating of product such as the cooking of starch or protein during the dispersion cycle. Height of the mill is 11 ft. Total weight empty, approx. 4 tons.

Knowlton Brothers

Durkee Technical Assistant

Myron C. Durkee has joined Knowlton Brothers, Watertown, N. Y., manufacturers of specialized papers for industry, as technical assistant to the production vice-president. In the newly created post, Mr. Durkee will assist in the management of the plant's production facilities.

Mixing Equipment Co., Inc.

Lightnin Mixers

Two bulletins describing the new RE Series of top-entering Lightnin Mixers have been released by Mixing Equipment Co., Inc., Rochester, N. Y. Bulletin B-522 describes the REC closed tank mixers, and Bulletin B-523 covers the REQ open tank line.

The RE is a complete mixer with a solid drive shaft, which is coupled directly to the mixer shaft. Features include right angle drive, precision bevel gears, change gears, integral stuffing box and easy maintenance.

Monsanto Chemical Co.

New Organophosphorus Flame Retardants

Six new organophosphorus flame-retardant additives which could prove economical and efficient in a broad range of polymeric systems as well as in synthetic fibers, rayon, paper and wood products have been announced by the company.

Trademarked Phosgard, the flame retardants are reaction products of phosphorus trihalides, alkylene oxides, aldehydes or ketones. They are reported to combine high halogen and phosphorus content and excellent compatibility with a wide variety of polymers.

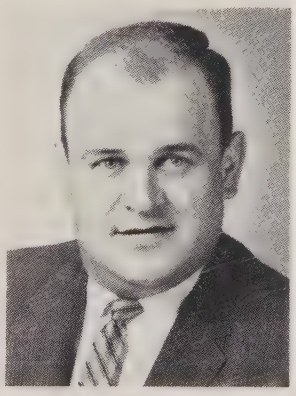
Standard tests have shown the clear, essentially odorless compounds to be effective flame retardants in such resin systems as polystyrene, polyesters, phenolics, acrylics, epoxies, polyurethanes, and polyolefins, when added in concentrations of 3 to 25% by weight, depending upon the polymer type.

The six new flame retardants have been designated Phosgard C-22, C-22-R, C-32, C-32-R, B-52-R, and B-20. The "C" series (denoting chlorine) are available now in evaluation quantities with Phosgard C-22-R obtainable in drum lots. Evaluation quantities of the "B" series (denoting bromine) were expected to be available by October 15.

Mount Vernon Mills

Dryer Felt Division

B. C. Aldrich has been appointed to head a new Dryer Felt Division. Mr. Aldrich went to Mount Vernon three years ago as technical adviser on drier felt development and before that he had been in the Industrial Sales Development division of du Pont, working with the paper industry. He will be located at Mount Vernon Mills, Baltimore, Md., office at 201 E. Baltimore St.



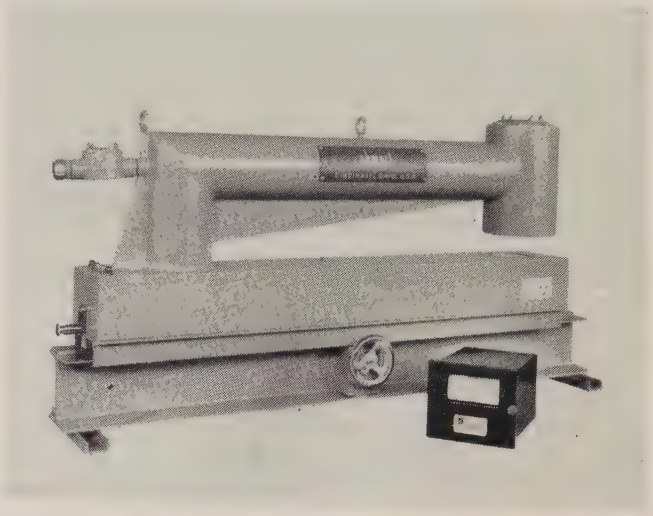
B. C. Aldrich, Mount Vernon Mills

According to Mount Vernon the new drier felt division has been set up in order to establish a closer relationship between the mill and the customer, and is designed to shorten the communication lines between the two.

The Ohmart Corp.

New Beta Radiation Thickness Gage

Ohmart's beta ray gage for measuring thickness variations in sheet materials during processing features a miniaturized transistor power supply indicator. The elimination of vacuum tubes in the power supply indicator results in a simplified circuitry thus decreasing space required and lessening maintenance.



Ohmart's transistorized beta ray thickness gage

Further information may be obtained from The Ohmart Corp., 2236 Bogen St., Cincinnati, 22, Ohio.

Owens-Illinois

21st Corrugated Box Plant Completed

Owens-Illinois Paper Products Division recently opened its 21st corrugated box plant, an ultra-modern, 150,000-sq. ft. facility, in Valley Industrial Park near the Twin Cities of Minneapolis and St. Paul.

The plant, the first to be completed in the new industrial area near the communities of Shakopee and Savage, initially will be capable of converting roll stock and producing boxes at a rate of 30 million square feet monthly. This is a tenfold increase over the capacity of the Owens-Illinois plant in St. Paul which closed when the new facility became available.

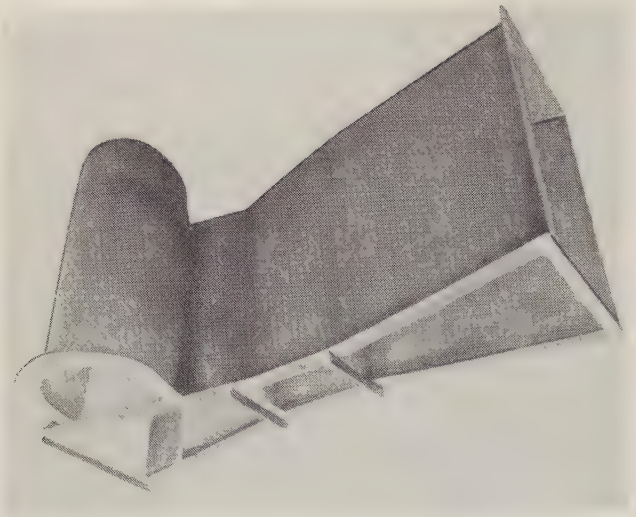
Plasti-Fab

Automatic Proportional Sampler

An automatic proportional sampler for measuring waste, process, or stream flow has been developed by Plasti-Fab of Portland, Oreg. The new sampler is said to be the most compact package available. There is a slow-speed pumping unit delivering a sample continuously to a plastic splitter box. The splitter box is part of the instrument housing which can be mounted above a sample bottle or a refrigerator if samples are to be chilled. The unit takes samples at the splitter box automatically proportional to flow utilizing signals transmitted by the flow meter. Sample size and frequency is adjustable over a range of 2000 to 1.

Housings are of constructed plastic and aluminum to resist corrosion and are purged with air to prevent corrosion of electrical parts.

The manufacturer points out that by continuously sampling the stream, sediment buildup is negligible. By using the splitter box, small samples may be obtained which ac-



The Parshall Flume, built by Plasti-Fab of Portland, Ore.

curately represent the condition of fluid passing the sample point. Additional information can be obtained from Plasti-Fab, P. O. Box 5941, Portland 22, Oreg.

New Parshall Flumes

Parshall flumes, built of corrosion resistant fiberglass reinforced polyester, are now in operation on industrial waste and municipal sewage.

These new flumes have throat sizes of 3, 6, 9, and 12 in., and are available with or without integral float wells and molded in level gage. Ends are flanged for bolting. These light-weight, self-supporting units (the 3 in. size weighs approx. 15 lb., the 12 in. approx. 45 lb.) are being used for measuring flow of waste in industrial plants where concrete would normally be eaten out by acid conditions.

On some municipal installations, small flumes have been installed to measure sewage from specified districts with an eye to future growth. When a larger flume is required, the small unit may be removed and a larger one installed. In other cases, small flumes have been installed inside existing oversize flumes awaiting the time when flows increase.

Pyroxylin Products, Inc.

New Cement for Plastics, Glass or Metal

Proxseal adhesive No. 37-164-8 is claimed to be effective as either a wet bonding cement, or when applied to the individual surface, dried and subsequently solvent activated to accomplish the seal. Proxseal cement can be used with equal success on similar or on mixed surfaces including vinyl, saran, pliofilm, rubber, polymer coated cellophane, and glass, as well as a variety of metals. Additional information is available from Pyroxylin Products, Inc., Chicago 32, Ill.

Ralston Purina Co.

Southern Sizing to Represent Company

The Southern Sizing Co., East Point, Ga., has been appointed sales representative for Purina's isolated soy protein products, Pro-Cote and Purina Protein, throughout the southeastern United States.

Raybestos-Manhattan, Inc.

Burrows—45 Year Manhattanite

H. H. Burrows, senior vice-president, rubber sales, was honored by officials and his associates at the Manhattan Rubber Division, Raybestos-Manhattan, Inc., Passaic, N. J., on his 45th anniversary with the company. He joined the Manhattan Rubber Division in 1915, later became manager of the Roll and Tank Departments, then sales manager of

Presenting 45-year pioneer lapel pin with four diamonds. Left to right: J. N. Kuzmick, Manhattan Division Manager, H. H. Burrows, R. B. Hazard, vice-president, and J. F. D. Rohrbach, president

Industrial Rubber Products Division and was appointed vice-president of the corporation Jan. 19, 1955.

J. O. Ross Engineering

Seven Employees Retire

Seven employees of the J. O. Ross Engineering Division of Midland-Ross Corp. were honored on their retirement at special ceremonies held recently at several of the Ross district offices.

In New York, those retiring were Oscar Byron, Jane Falasca, Jim Holt, Henry Voelker, and Alex Smirnoff.

Harold Warman retired from the Mount Prospect, Ill., office, and Frank W. Partsch retired from the Boston office.

In the district offices service awards were given to 72 Ross employees with the company 20 years or more, including 30 who have been with Ross Engineering 30 years or more.

Solvay Process Division, Allied Chemical Corp.

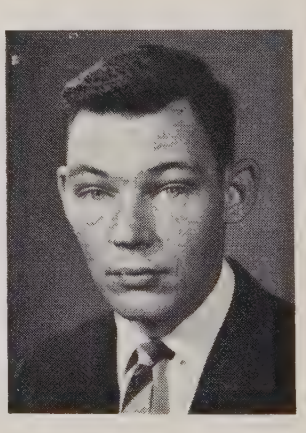
The company plans to expand its mercury cell chlorine-caustic soda plant at Brunswick, Ga. The new facilities will increase chlorine-caustic soda production capacity by approximately 100 tons per day.

This will be the second expansion of the Brunswick plant since it was constructed in 1956. Solvay also has chlorine-caustic soda facilities at Syracuse, N. Y.; Baton Rouge, La.; and Moundsville, W. Va.

A. E. Staley Mfg. Co.

Appointment

Kenneth C. Damp has been named to a new position in the paper sales department as a paper technical sales representative. He will soon be assigned a new territory in the company's southern region.



Kenneth C. Damp, A. E. Staley Mfg. Co.

The Tayler Corp.

Linzell Returns from Taiwan

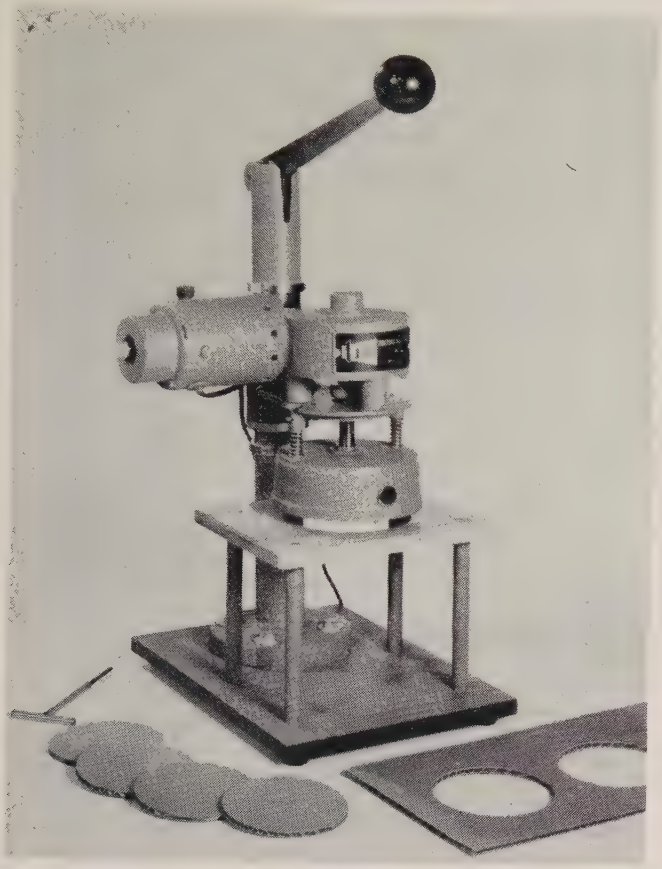
Harry K. Linzell, vice-president and chief engineer of The

Tayler Corp., Elizabeth, N. J., has recently returned from Taiwan, where he had been invited by the Taiwan Sugar Corp. to advise them on the revision of their process so as to make salable hardboard.

Testing Machines, Inc.

Power Operated Circular Sample Cutter

The samples are prepared without exposing the material to any compressive force. Developed to fill the need for a fast, accurate method of preparing flat crush test samples, this



Power operated circular sample cutter, TMI

power operated cutter can be used also for preparing samples having an exact area or diameter for making weight tests, moisture vapor transmission tests or other tests where a circular sample with an exact area is needed.

For complete details write to Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y.

Warren Pumps, Inc.

Test Facilities Expanded

Work has been completed on an expansion of pump test facilities, both production and experimental, at the main plant of Warren Pumps, Inc., Warren, Mass. The capacities of both the centrifugal pump and the rotary pump test departments have been nearly doubled by the completion of the project.

H. Waterbury and Sons Co.

Annual Sales Meeting

Discussions on the latest developments in felt manufacturing and an inspection of new mill equipment were highlights of the meetings held for sales representatives at H. Waterbury and Sons Co., Oriskany, N. Y., August 15 through August 19. Sessions were conducted by the production and technical staffs to familiarize the sales personnel with the

H. Waterbury and Sons Company Sales and Technical personnel attending 5-day Sales Meeting included, left to right: Clarence F. Robinson, technical consultant; Joseph H. Kellner, eastern representative; Robert S. Greene, sales manager; John C. Leidy, Pen-jer-del representative; Jerry Roslund, west coast representative; R. C. Plumlee, southeastern representative; Clarence C. Brown, southwestern representative; Fred W. Kopplow, midwestern representative; John K. Coppens, midwestern representative; Walter S. Dempsey, technical consultant; Stephen J. Elkins, New York State representative

expansion in production facilities and the advances being made in a new type of felt.

The sales seminars were under the direction of Robert S. Greene, sales manager. Outdoor clambakes, visits to trotting races and golf at the Yahnundasis Golf Club were features of the five-day sessions.

General

Foreign Market Surveys

The Export Committee of the American Paper and Pulp Association has issued the first of its new series of foreign markets for paper and paperboard. This detailed market analysis covers Australia, Colombia, Mexico, New Zealand, Union of South Africa, and Venezuela and are supplements to originals issued in 1953, 1955, and 1956. Of special interest to export minded companies are the specific sections on printing and writing papers, wrapping papers, sanitary papers, food packaging paper and boards, and building papers and boards. Each country report contains a section on special market opportunities for paper and paperboard and market outlook.

This new report is part of the Export Committees' continuing program of supplying industry with current world market data and trade opportunities, and are prepared in cooperation with the Pulp, Paper and Paperboard Subdivision, Forest Products Division, Business and Defense Services Administration, U. S. Department of Commerce and the Foreign Service of the United States.

46th

Annual Meeting

TAPPI

Hotel Commodore, New York, N. Y.

Feb. 19–23, 1961

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Research and Development Division

Forest Biology Committee

The fourth meeting of the TAPPI Forest Biology Committee was convened at 4:40 p.m. Aug. 26, 1960, at the New Washington Hotel, Seattle, Wash., by Chairman Donald D. Stevenson. Fourteen members of the committee, two interested guests, and two members of the TAPPI staff attended.

Chairman Stevenson commented on the Forest Biology Conference, the indoor sessions of which had just been concluded, and expressed for the committee as a whole its appreciation to Bob Seidl, Jack Duffield, Bruce Zobel, Hans van Buijtenen, Ben Jayne, Bob Callsham, and Rollie Sultze for their work in arranging the conference.

The major items of business conducted in the committee meeting of August 26 are summarized in the following sections of these minutes.

Membership Changes. Chairman Stevenson noted the resignation of Thomas O. Perry from the Forest Biology Committee. He then mentioned the recent change of position and new duties of Fred E. Pollock of Buckeye Cellulose, and suggested for Pollock the possibility of replacing him on the committee with Louis A. Hiett, also of Buckeye Cellulose. There followed a short, positive discussion of this change, following which Ellis moved and Joranson seconded a motion that Hiett be made a member of the committee replacing Pollock. The motion carried unanimously. (The discussion and the motion inferred that Chairman Stevenson, a fellow employee of Hiett and Pollock at Buckeye Cellulose, would notify these men of the committee action.)

Size of Committee. The size, makeup, and activity of members of the Forest Biology Committee was discussed at some length in connection with the suggestion that H. E. Dadswell, of the Division of Forest Products, C.S.I.R.O., Melbourne, Australia, be invited to membership on the committee. Besley moved, Wangaard seconded, and the members present voted unanimously that this invitation be extended Dr. Dadswell by the chairman.

Returning to size, etc., of the committees, Joranson noted that its original size was about 35 members. Driver commented on the TAPPI policy of activity on the part of members if committee membership is to be retained; and Zobel raised a question about how and by whom inactivity of committee members is handled. In this connection, Besley commented on membership on the committee for a fixed term. Winchester, of the TAPPI staff, noted that membership on TAPPI Committees is for a term of 1 year, that committee chairmen appoint or reappoint members, and that members can and should be asked to acknowledge formally their willingness to serve at the time they are appointed.

Stevenson noted that Besley is at present the only Canadian member of the Forest Biology Committee. Besley remarked that he is not as much interested in geographic representation on the committee as he is the spread of committee activities and the present or potential members who might broaden and intensify these activities. Noting that the present trend of committee activity almost demanded that the forest scientist members be either geneticists or wood technologists, Besley suggested that future activities might call for silviculturists as well. Duffield, agreeing with the idea, remarked that it was one of the major determinants in giving the committee its rather broad, all-inclusive name rather than one more specific.

The discussion on membership ended with the observation by Chairman Stevenson that these matters tied in with future work of the committee, to be taken up later, and that the overall subject would be deliberated more thoroughly between now and February, 1961, and discussed in detail at the New York meeting then.

Report of Subcommittee 1 on Bibliography. Larson, chairman of Subcommittee 1, reported a meeting of his subcommittee on Aug. 24, 1960, to go over publication plans for the bibliography that is almost completed and assembled. Larson is quite hopeful that final assembly and printing can be done this winter.

Besley wondered if the information put together by Subcommittee 1 could be punched on IBM cards and kept up to date, and if the Oxford Decimal Classification system should not be used. Larson said that all the information is on Keysort cards, and these can be supplied to anyone who might have the time to classify these according to the Oxford system and enter the information on IBM cards. Chairman Stevenson asked if Besley and Larson could jointly look into the possibility of doing this.

Report of Subcommittee 2, on Tests and Quality Objectives. Joranson, chairman, reported briefly on a short meeting of Subcommittee 2 on Aug. 25, 1960. He commended Thode for his presentation of the Subcommittee Report No. 1 at the Forest Biology Conference, mentioned the subcommittee's discussion of a possible expansion of its activities in the field of small sample testing of wood, and opened up the involved subject of further publication of report no. 1. (This report is to be published in TAPPI; Subcommittee 2 and the committee as a whole are desirous of having it published more widely so as to reach a wider reading audience.) The discussion dealt with the possibilities of preparing a condensation of the report for certain journals, and offering the report to various other magazines and journals (such as *The Forest Farmer, Pulp and Paper International,* and the *Journal of the Forest Products Research Society*) for publication in toto. Chairman Stevenson is to investigate these possibilities.

Next Meeting of Committee. Chairman Stevenson, noting the advantages of Paper Week for a joint meeting of foresters and papermakers, asked for opinions as to a technical session or a simple business meeting of the committee at that time. Driver and others thought the conference just concluded was excellent, but enough for one year. The sense of the discussion was that a business meeting only should be held this coming February. Besley invited the committee to hold this meeting just ahead of Paper Week at the Pulp and Paper Research Institute of Canada, at Montreal, and Chairman Stevenson said this invitation was appreciated and would be considered.

Joranson thought the committee should plan another conference, perhaps in 1962. Joranson also suggested that one to three papers on forest biology might be scheduled for one of the general sessions of TAPPI at Paper Week; Winchester agreed that this might be desirable, and Chairman Stevenson said he would explore the possibility more fully in the near future.

Future Work of Committee. Chairman Stevenson opened the subject of future work of the Forest Biology Committee by asking the group for its thoughts on environmental as well as genetic influences on wood quality. He suggested the possibility of a third subcommittee for work along this line. The ensuing discussion was fast, involved, and difficult to record.

Besley spoke to the point of consideration of environmental factors along with genetic factors as they affect wood quality. He postulated a classification scheme by which a forester could recognize and measure those tree characteristics that bear on wood and fiber characteristics so as to enable him to supply the papermaker with a wood mix of specific qualities that might be desired. It was his thought that the committee might stimulate or lead investigations that would eventually result in a "fiber index." Joranson agreed with Besley's ideas, but wondered mildly about the priority of such work. Besley reiterated his feeling that the silvicultural or environmental influences on wood, pulp, and paper properties were eminently worthy of immediate consideration in forest regions such as Canada where improvement through genetics is a long way off.

Echols, Einspahr, van Buijtenen, and Wangaard discussed briefly the idea of using models or specific category classifications for describing and studying specific characteristics of trees, wood, or pulp.

Chairman Stevenson asked for ways of resolving this important and interesting discussion. Driver suggested that the committee take this up in greater detail at its February meeting, and that members be prepared to discuss it more fully at that time. Joranson suggested that the committee go on record as being in favor of the early and accelerated initiation of critical experiments with ideal material in order to make more rapid advancements in the improvement of wood quality through biology. He further recommended that this approach be recommended to appropriate research organizations. The committee reacted favorably to Joranson's suggestion without the formality of a motion or vote.

J. W. Johnson, *Secretary*

Statistics Committee

The Statistics Committee held a meeting during the TAPPI Annual Meeting on Feb. 22, 1960.

M. S. Renner has been appointed chairman and W. E. Carlson, secretary of the TAPPI Statistics Committee for the year 1960–61 by the Chairman of the Research Development Division of TAPPI.

Reports of Subcommittees

TAPPI-CPPA Statistics Course. Chairman Renner reported on the 1959 TAPPI-CPPA Statistics held at Dartmouth College, Hanover, N. H., July 20–31. In attendance were 22 for the basic course and 12 for the advance seminar. Geoffrey Beall and Fred Sheldon conducted the basic course. Dr. Mandel and Prof. Wormleighton conducted the advance course. A net favorable balance was reported for the course.

The Ninth TAPPI-CPPA Statistical course will be offered at Brevard College, Brevard, N. C., August 8–19, 1960. The course will be cosponsored by TAPPI-CPPA and the Institute of Statistics of North Carolina State College. Professor Robert Hader of North Carolina State College will be one of the instructors and other instructors will be selected.

Dr. Lewis, chairman of the TAPPI Research and Development Division, spoke to the committee concerning a National Science Foundation Conference dealing with application of statistics by teachers in their courses. The title of the conference is "New Application of Mathematics and Statistics in the Design and Operation of Complex Systems" for college teachers of mathematics, science, engineering. The conference will consist of lectures, case studies, and workshops devoted to developing the mathematical and statistical tools and illustrating their applications by means of actual case studies in industrial and military organizations. Director of the conference is Burton V. Dean, Operations Research Group, Case Institute of Technology, 10900 Euclid Ave., Cleveland 6, Ohio. The National Science Foundation grant to the conference covers the cost of tuition, fees, stipends, and travel allowances. The teacher participants are selected by the specific conference, in other words, by the Case Institute of Technology. The stipends run approximately $15 per day, and the travel allowances will not exceed $80. Dr. Lewis suggested that the TAPPI Statistics Committee sponsored scholarships to this conference for instructors in pulp and paper schools. It was moved by John Lashof, seconded by Fred Sheldon that the TAPPI Statistics Committee provide in its 1960 budget two scholarships including this and travel expense for instructors from pulp and paper schools. Motion was carried.

Sampling Planning Subcommittee. Mr. Hoffman reported by letter that during 1959 the committee had appointed D. M. Gilmore, Brown Com., as coordinator of the sampling plan survey. The details of the survey were outlined by Mr. Gilmore to include five grades of uncoated paper. Mr. Carlson reported that the data from the first trial had been calculated and a preliminary report prepared from the very limited amount of data. The similarity of occurred spot and wrinkle was found to agree with past experience and was believed good. It was recommended that a meeting be held by the committee to consider modifying the sampling plan since the plan as outlined initially does not seem to be suited for some types of finishing operations.

Publication Committee. Mr. Fuller, chairman, reported that copies of "Methods of Statistical Evaluation of Test Results" had been submitted by Mr. Patek, Eastman Kodak Co., and copies were available to committee members. He also reported that Hercules Powder Co., Rohm and Haas, and American Cyanamid Co. had statistical publications available. Mr. Fuller commented that the CPPA publication "Introduction to Statistics Methods as a Solution to Industry Problems" mentioned in last year's minutes was not yet available. Mr. Fuller expressed his desire to compile a functional organization chart which will outline in more detail course of action and support of projects by the committee.

Quality Control Subcommittee. J. F. Theriault was not present to report on the activities of the committee. L. E. Collison expressed his feelings that an emphasis should be placed on quality control by the Statistics Committee. Mr. Langmaid suggested that because of the wide interest in quality control, that TAPPI establish a separate quality control committee, perhaps in the Engineering Division, to emphasize such things as organizational aspects of quality control, methods, procedures, and the like.

Design of Experiments Subcommittee. Chairman, J. G. Strieby was not present and no report was available.

New Business

F. R. Sheldon moved, seconded by M. E. Blew that the Tenth (1961) TAPPI-CPPA Statistics course be held in Canada—carried. Queens University in Kingston and University of Toronto were suggested as possibilities. It was moved by F. R. Sheldon, seconded by D. M. Gilmore, that the members of the Statistics Committee express their appreciation to K. E. Vroom for his excellent work as co-chairman of the Statistics Course Subcommittee—carried. Chairman Renner stated a new co-chairman for Canada would be appointed by June 1, 1960, to replace Dr. Vroom.

Chairman Renner presented for committee consideration that TAPPI-CPPA sponsor an EVOP course similar to the ASQC courses given during the past three years. R. A. Joss stated that the CPPA would not be interested in participating in such a project. Thereupon, J. M. Patek moved, seconded by F. R. Sheldon, that the TAPPI Statistics Committee recommend that TAPPI cosponsor with ASQC an EVOP course during 1960 or 1961—carried.

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Subjects for the 1961 annual meeting were discussed concluding with this recommendation that one session should deal with general subjects as quality control, design of experiments, etc., and a second session be devoted to sampling plans.

WILLARD E. CARLSON, *Secretary*

SUPPLEMENT TO MINUTES

On Tuesday morning, February 23, a meeting of interested people was held to discuss and plan possible activities of the TAPPI Statistics Committee in the area of quality control. Present were Fuller, Hartwell, Lace, Langmaid, M. H. Nuntz, M. S. Renner. (Theriault planned to be present but was unavoidably detained at another committee meeting.)

Objectives were agreed to be as follows:

1. To provide a mechanism for communications and cross-fertilization of ideas about quality control in the paper industry specifically.
2. To help people now using quality control procedures to develop more effective and more profitable quality control setups.
3. To show people not now using modern quality control procedures how to go about setting up an effective and profitable quality control operation.

It was agreed to define quality control for purposes of this discussion along the following lines:

1. Quality control is a management, organizational and engineering, as well as statistical problem. Statistics amounts to somewhere between 10 and 40% of the process.
2. Emphasis should be on the economics of quality control, i.e., quality control should be looked upon as total quality control from the point of view proposed by Feigenbaum of General Electric: quality costs—inspection, quality audit, spoilage, defect prevention, customer complaints and returns, process control directly related to quality, engineering, etc.—are considered and the objective is to allocate money for quality control work in the way which will give the lowest total quality costs. It was agreed that this would probably mean that one job to do would be to point out and emphasize the fallacy and costliness of statistics for statistics' sake or plotting control charts for the sake of plotting control charts.

Activities—Several possible activities were suggested as follows:

1. Run a two-day seminar-type session on total quality control.
2. Work through local ASQC members from the paper industry.
3. Have a series of meetings on quality control attended by people working in the field.
4. Pick four or five mills now doing a good job of quality control and arrange for formal plant visits.
5. Prepare a list of mills now using quality control that interested people might visit.
6. Hold a general meeting on quality control at which speakers would bring in slides and materials to show what they are actually doing.
7. Have TAPPI sponsor an ASQC quality control for management session.
8. Have the Publications Committee send out a series of reprints of articles dealing with the organization and management aspects of quality control.
9. Send out a quality control questionnaire.

Decisions—it was decided to do the following:

1. Hartwell will try to find people from each ASQC district who are willing to do work in establishing a nucleus of people in each ASQC district who are interested in quality control in the paper industry.
2. Renner will investigate the workability of the plan to have ASQC give its quality control for management course for TAPPI members. It was pointed out that this is an expensive course, aimed at management people, and designed to give instruction in organization and management of the quality control function.
3. Renner and Hartwell will prepare a simple questionnaire for submission to TAPPI corporate membership. Purpose of this questionnarie would be to find degree of interest in quality control, areas of interest and problems, and interest in attending general seminar-type sessions, either regional or national.
4. A committee meeting to plan this session or sessions will be held in Boston. It was agreed that it should be at tempted to get the widest possible representation at this meeting. It is suggested that all people interested in attending communicate with Fred Hartwell.
5. Fuller will study the possibility of preparing a series of reprints dealing with organizational and management aspects of the quality control function for distribution to the TAPPI membership as a TAPPI report.

M. S. RENNER

Power Requirements of Feltless Pulp Machines

Final Report—Project No. 620

C. C. COLLINS and G. E. CLINK

The Electrical Engineering Committee of TAPPI appointed a subcommittee to investigate the power requirements of feltless pulp machines. Power data questionnaires were made up and sent to pulp mills operating pulp machines. These questionnaires were completed by the mills, then studied and evaluated by the subcommittee. This report includes the subcommittee recommendations for power requirements for driven rolls on feltless pulp machines, an explanation as to how the recommended drive constants were selected, and a tabulation of the power data given on the questionnaires.

In November, 1956, the Electrical Engineering Committee of TAPPI assigned a subcommittee to investigate power requirements for feltless pulp machines. A power data questionnaire was then prepared and mailed, in November, 1957, to 15 mills having this type of equipment installed. Twelve mills answered the questionnaires and returned them to the subcommittee. The last completed questionnaire was received by the subcommittee in the fall of 1959.

The feltless pulp machines studied were similar in most respects. They consisted of a cylinder mold, two presses, a predrier, a cutter, and in most cases an air drier.

Power constants for each driven roll are expressed in horsepower per inch width per 100 f.p.m. The machine width is taken as the width of the cylinder mold. Two constants for each driven roll were considered, first the normal running load (NRL) constant and, second, the recommended drive constant (RDC).

The NRL constant represents the power flowing into a driven roll under normal operating conditions of pressure, sheet weight, vacuum, tension, etc. On a given machine the NRL may change from day to day depending on how the machine is being operated, the condition of the equipment, and changes in other variables.

In selecting a drive for a pulp machine these differences in operating power requirements must be recognized. In previous studies the TAPPI committees recognized the variations in drive requirements for different machines and instigated a series of recommended RDC's for various driven rolls on pulp and papermaking equipments. These constants are a valuable aid to mills and suppliers for the proper selection of machine drives. The value of the RDC must be assigned with care and practical judgment to make it valid for use. The RDC assigned is large enough to accommodate expected operating conditions yet is not large enough to overcome severe abnormal conditions.

TABULATION OF DATA

Information obtained from the questionnaires has been tabulated and reproduced in Table II. Because of the small number of mills and machines involved the machine width, design speed, and operating speed have been omitted from the tabulation to help prevent mill identification.

EVALUATION OF DATA

After examination of the load data given in the questionnaires, normal running load constants were calculated for each machine. A study of the running loads and machine variables led to the assignment of recommended drive constants. These constants are tabulated in Table I. In addition to recommended drive constants the tabulation includes the minimum, average, and maximum normal running loads for each driven section.

Cylinder Mold

Normal running load on molds with three pressure rolls varied from 0.044 to 0.106 hp. per in. width per 100 f.p.m. In general, load increased with nip pressures and vacuum; however, several machines required more power at the mold than similar machines with higher pressures and vacuums. The more rolls on mold the higher the load. One machine with four pressure rolls had an NRL of 0.134 hp. per in. width per 100 f.p.m.

It is believed that the majority of mills installed in the future will have cylinder molds of at least 96 in. diam. and have capacity for high nip pressures and vacuum. With these assumptions it is logical to assign a recommended drive constant of 0.12 hp. per in. width per 100 f.p.m. to the mold with three pressure rolls and 0.15 hp. per in. width per 100 f.p.m. with four pressure rolls. This constant is approximately 20% greater than the highest observed normal running load.

Presses

Some pulp machines are designed to have a first press that

Table I. Power Requirements for Feltless Cylinder Mold Pulp Machines

Section	*Horsepower per in. width per 100 e.p.m.* NRL[a] Minimum	Average	Maximum	RDC[b]
Cylinder mold				
With 3 pressure rolls	0.044	0.071	0.106	0.12
With 4 pressure rolls	...	...	0.134	0.15
Presses				
Up to 1800 lb./in. pressure	0.136	0.188	0.32	0.30[1]
Above 1800 lb./in. pressure	0.186	0.256	0.36	0.35[1]
Predriers				
2–60-in. rolls	0.003	0.008	0.014	0.03
2–48-in. rolls	0.0014	0.004	0.005	0.03
Pull rolls (for conveyor drier)	...	...	...	0.02[2]
Conveyor drier (9 conveyors)				
Single motor	0.023	0.034	0.04	0.06
Multiple motors (9 motors) each	0.004	0.009	0.019	0.02
Cutters	0.026	0.033	0.05	0.06

[a] NRL = normal running load.
[b] RDC = recommended drive constant.
1. The RDC for presses is to be considered as a minimum value.
2. If separately driven—refer to evaluation of data.

Charles C. Collins, General Electric Co., Schenectady, N. Y.; and George E. Clink, Chief Development Engineer, Sandy Hills Iron and Brass Works, Hudson Falls, N. Y.

is limited in nip pressure to 1800 lb. per in. width or less. Most second presses will have capacity for higher nip pressures with the maximum reaching approximately 3000 lb. per in. width. Since the first and second presses may be designed for two different maximum nip pressures, two different recommended drive constants have been assigned. One constant for use with nip pressures up to 1800 lb. per in. width and the other for use with nip pressures above 1800 lb. per in. width.

In general, the power requirement for a first press is 30 to 40% higher than would be required for a second press operating with the same nip pressure on the same weight sheet. It is believed that the work done on compressing the pulp mat at the first press accounts for this power differential. The thickness of the pulp mat entering the first press will have an effect on the power required at that press. As noted above, the second press will operate at higher nip pressure than does the first press and in general will require more total power than does the first press. Where duplication of drive equipment is desirable both presses should be powered corresponding to the largest recommended drive constant.

The first press on the no. 5 machine was operated at 2700 lb. nip pressure. This unusually high nip pressure at the first press position had a correspondingly high power requirement of 0.35 hp. per in. width per 100 f.p.m. The press power data for the no. 9 machine is unusually high for both presses considering pulp weight, nip pressure and press position. The first press operating at 1810 lb. per in. width nip pressure had a power requirement of 0.432 hp. per in. width per 100 f.p.m. This is 75% higher than the power requirements of other first presses operating at about the same nip pressure on similar pulp sheets. The second press power requirement for this machine was also correspondingly high. Since the press power requirements on the no. 9 machine were as high compared to all other machines, the press data were considered void.

The press load data on the no. 12 machine shows running loads slightly larger than the selected recommended drive constants. There does not appear to be any reason for high press power requirements on this machine unless it is a result of the heavy weight sheet of 450 lb. per 1000 ft. All other presses were running at least 15% below the recommended drive constant. Since press loading can be reduced slightly if overload conditions are encountered, the press-recommended drive constants were selected with margin over the average expected load and not over the maximum observed load.

Motors for presses should never be selected below a rating corresponding to the recommended drive constant and if a pulp sheet of 400 lb. per 1000 sq. ft. is to be made then consideration should be given to increasing the recommended drive constant by 15%.

Predriers

A recommended drive constant of 0.03 hp. per in. width per 100 f.p.m. was selected for two predrier rolls, either 48 or 60 in. diam. This constant is approximately two times the highest normal running load reported. While the selection of the RDC is conservative, the added horsepower and

Table II. Operating Data—Feltless Cylinder Mold Pulp Machines

Machine no. →	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
General												
Type of pulp	Kraft	Sulfite	Kraft	Sulfite	Kraft	Kraft	Kraft	Kraft	Kraft	Kraft	Kraft	Kraft
Pulp weight, lb./1000 sq. ft.	333	333	210	244	430	401	317	380	410	367	...	...
[a]Machine constant, in. width × f.p.m./100	87	76	99	92	119	101	105	134	131	88	85	173
Cylinder mold												
Prepress nip, lb./in. width	18.4	30	61	19	25	25	17.5	28	55	25	...	25
Press nip, lb./in. width	125.0	160	100	83	150	150	130	142	178	110	...	150, 170
Couch nip, lb./in. width	150.0	40	39	12	175	175	10	119	167	130	...	180
Vacuum, in. Hg	5.25	18	12	15	15	15	12	6	21	17.5	...	18
Diameter, in.	96	79	136	79	...	...	96	114	96	96	...	...
Type bearings	AF	AF	AF	AF	AF	AF	AF	AF	Plain	AF	...	Plain
Operating horsepower	6.85	3.64	4.31	4.75	12.5	8.95	7.77	7.3	12.8	2.32	...	23.2
[b]NRL, hp./in. width/100 f.p.m.	0.079	0.048	0.044	0.052	0.106	0.088	0.075	0.055	0.098	0.026	...	0.134
First press												
Type bearings	AF	Plain	Plain	Plain	Plain	Plain	AF	Plain	Plain	Plain	...	AF
Nip pressure, lb./in. width	1000	1800	1700	1900	2700	2000	1350	1935	1810	2250	...	1800
Operating horsepower	11.8	10.5	18.3	25.0	41.5	31	21.3	33.5	56.7	26.2	...	56
NRL, hp./in. width/100 f.p.m.	0.136	0.138	0.186	0.272	0.35	0.307	0.204	0.25	0.432	0.297	..	0.323
Second press												
Type bearings	AF	Plain	Plain	Plain	Plain	Plain	AF	Plain	Plain	Plain	...	AF
Nip pressure, lb./in. width	1500	2700	2700	2850	2100	2100	2015	2625	1690	2250	...	2800
Operating horsepower	14.3	16.0	18.3	20.3	29	22	26.2	38.8	39.1	19.3	...	62.4
NRL, hp./in. width/100 f.p.m.	0.164	0.21	0.186	0.221	0.245	0.218	0.25	0.29	0.298	0.219	...	0.36
Predrier												
Diameter, in.	60	48	48	48	60	60	60	48	...	...	...	60
Number drums	2	3	2	1	2	2	2	2	...	...	...	2
Type bearings	AF	Plain	Plain	Plain	Plain	Plain	Plain	AF	...	...	...	AF
Operating horsepower	1.21	0.4	0.418	0.3	0.79	0.675	0.29	0.19	...	...	...	1.2
NRL, hp./in. width/100 f.p.m.	0.014	0.005	0.004	0.003	0.007	0.007	0.003	0.0014	...	...	...	0.007
Cutter												
Operating horsepower	2.28	3.7	2.5	2.47	3.14	2.7	...	4.6	6.8	...	...	7.45
NRL, hp./in. width/100 f.p.m.	0.026	0.049	0.025	0.027	0.026	0.027	...	0.034	0.052	...	...	0.043
Conveyor type air drier												
Number of conveyors	9	9	9	...	9	9	...	7	...	5	9	...
Length of each conveyor, ft.	137	...	107 1/3	...	135	135	...	120	...	108	145	...
NRL motor no. 1	0.004	0.042	0.020	...	0.014	0.008	0.01	0.038	0.019	0.023	0.006	...
no. 2	0.010	...	0.013	...	0.013	0.008	...	...	0.019	...	0.008	...
no. 3	0.017	...	0.009	...	0.013	0.008	...	...	0.019	...	0.004	...
no. 4	...	...	0.008	...	0.018	0.008	...	...	0.019	...	0.006	...
no. 5	...	...	0.006	...	0.011	0.008	...	...	0.019	...	0.007	...
no. 6	...	...	0.009	...	0.011	0.008	...	...	0.019	...	0.010	...
no. 7	...	...	0.008	...	0.011	0.008	...	...	0.019	...	0.009	...
no. 8	...	...	0.005	...	0.013	0.008	...	...	0.019	...	0.012	...
no. 9	...	...	0.004	...	0.013	0.008	...	...	0.019	...	0.009	...

[a] Based on operating speed, in f.p.m.
[b] NRL = normal running load.

cost in this range is quite small. It is believed that the additional drive capacity for starting, better tracking, and operation under most conditions is enough to justify the small added cost in drive selection.

Conveyor Driers

Recommended drive constants for conveyor air driers either single or multimotors were selected with nominal margin over reported maximum running loads.

Cutters

Recommended drive constants for cutters were selected with nominal margin over reported maximum running loads.

Pull Rolls

On multimotor conveyor driers the entry and exit pull rolls will normally be driven by separate motors. The power requirement for these pull rolls should be considered the same as for each of the conveyors. This corresponds to a recommended drive constant of 0.02 hp. per in. width per 100 f.p.m.

Those installations having conveyor driers driven by a single motor will normally have the entry pull rolls mechanically connected to the conveyor and ample power is included in the drier constant to accommodate pull rolls. The exit pull rolls on this type installation is normally connected to the cutter and is driven by the cutter motor.

Presented at the Fifteenth Engineering Conference of the Technical Association of the Pulp and Paper Industry, Jacksonville, Fla., Oct. 24–28, 1960.

Questions and Answers

Good engineering questions are solicited as well as answers or alternate answers to the published questions. Material should be sent to TAPPI Headquarters, marked for the attention of H. O. Teeple. The items contributed will be forwarded to the Question and Answer Committee for processing. If comments are to be contributed, please refer to the question number.

(1-11/60) *Question:* **How should you check the water level in a water column?**

(*1.1-11/60*) *Answer:* There are two ways to check water level in a water column: (1) In a steaming boiler, blow the column and gage glass. Then observe if piping and connections are free. If they are, water will return quickly to steaming level. (2) In a cold boiler, examine the piping for leaks, cracks, or improper pitch. Verify the relative position of the water column to the heating surface (top of tubes or furnace) of the boiler by sighting or measuring. Then try all valves and gages to make sure they are working freely.

(2-11/60) *Question:* **Two steam gages are exactly alike and both are dead-weight-tested to read alike. One gage is mounted near the gage glass of a large boiler, the other on an instrument panel on the operating floor 20 ft. below. (1) After a short run, which gage will read high and why? (2) How is this corrected?**

(*2.1-11/60*) *Answer:* (1) The lowest gage will read high because condenstation will collect in the vertical gage line, causing 0.433 p.s.i. for each foot of column. (2) To correct this condition, reset the lower gage to read the same as the upper gage. Recheck, as the pressure varies when firing rates change at the upper gage range.

(3-11/60) *Question:* **Water causes knocks in steam lines. Explain.**

(*3.1-11/60*) *Answer:* Water in steam causes knocks because the steam is moving the water along at a great velocity, slamming it against fittings as the direction of flow changes. One fault is poor drainage. When opening the steam valves take great care to warm the lines ahead of them slowly enough to allow any condensed steam to drain from the cold line. Design piping runs to avoid low spots and dead ends. Provide enough traps and drains. Carryover from boilers is another cause of knocking. Slugs of water in the steam are very dangerous. The lines may rupture, or machines and fittings may be destroyed. Slugs of water in reciprocating engine cylinders are very bad, since water is noncompressible. Make sure that cylinder drains are open when warming up their steam lines.

(4-11/60) *Question:* **What is cathodic protection?**

(*4.1-11/60*) *Answer:* A zinc plate (galvanic protection) is usually used to maintain the effect of an electric cell. Galvanic action attacks the zinc instead of the boiler metal or heat exchanger. At times, tanks and piping are protected by a small current flowing in the most favorable direction. The material attacked is the anode and the material protected is the cathode.

(5-11/60) *Question:* **What must be done to burn fuel oil economically?**

(*5.1-11/60*) *Answer:* There are nine rules to remember when burning fuel oil. (1) Atomize the oil completely to produce a fine uniform spray. (2) Mix the air and fuel thoroughly. (3) Introduce enough air for combustion, but limit the excess air to a maximum of 20%. (4) Maintain a clean, steady supply of oil to each burner. (5) Keep the orifices and sprayer plates clean and in good condition. (6) Maintain the proper relation between the sprayer-plate nut and the diffuser hub. (7) Maintain the proper relation between the diffuser and the burner tile. (8) Keep the refractory throat tile in good repair. (9) Use the proper size of sprayer plate (for mechanical type) and the proper number of burners to accommodate the anticipated steaming load.

*(7.11/60) *Question:* **(Rotor Bar Comes Loose from End Rings): A squirrel-cage induction motor has two windings on the rotor, one for starting, one for running. Bars in the starting winding gradually break loose from the end rings. What effect does this have on motor-starting characteristics?**

*(*7.1-11/60*) *Answer:* Loose bars in the starting winding will reduce starting torque. If good connections cannot be maintained between bars and end rings by the method now used, weld the bars to the rings. This is common practice.

The questions and answers marked with an asterisk are reproduced courtesy *Power* magazine.

Sixteenth

Engineering Conference

TAPPI

Shoreham Hotel

Washington, D. C.

Oct. 15–19, 1961

Basis Weight of Paper and Paperboard

Proposed Revision of TAPPI Standard T 410 m-48*

(THIS STANDARD IS UNDER THE JURISDICTION OF THE PAPER TESTING COMMITTEE)

THE commercial standard for expression of the basis weight of paper in most English speaking countries has been the weight in pounds of a ream, usually of 500 sheets of a given size but occasionally 480 sheets. The metric system used elsewhere expresses the basis weight in grams per square meter. For convenience, this is now abbreviated to g.s.m. It is more explicit than pounds per ream when the ream size is omitted in writing or speaking.

The basis weight of paperboards is usually expressed as the weight in pounds per 1000 sq. ft. Generally, all heavy, stiff sheets over 0.012 in. thick, other than blotting paper, are considered to be paperboards. The term also includes materials of lesser thickness, such as liner, corrugating and chipboard.

APPARATUS

Balance with a sensitivity of 0.25%, or less, of the applied load and such that readings of this degree of accuracy can be made. The balance may be a specially constructed sheet-weighing device that indicates the equivalent weight in g.s.m., when one sheet of a given size is weighed; or the equivalent weight of 1000 sq. ft. of paperboard in pounds when one sheet 1 sq. ft. in size is weighed. For small samples an analytical balance is preferable.

Cutter. When a template is used for preparing specimen sheets, the paper should be cut to exact size with a sharp knife on a hardwood board. A paper cutter having an attachment for ensuring parallelism of the opposite edges is recommended.

CALIBRATION

Calibrate the balance not more than 30 days prior to the test, both with increasing and decreasing loads by applying accurate weights. Take care that after calibration the level of the balance is not disturbed. Select and condition the samples or specimens in accordance with TAPPI Standards T 402 m and T 400 m.

TEST SPECIMEN

Whenever possible the specimens should consist of not less than 10 sheets representative of the shipment each at least 500 sq. cm. (80 sq. in.) in area, and for paperboard, not less than five representative sheets each at least 1 sq. ft. in area.

PROCEDURE

Test the specimens in an atmosphere conditioned according to TAPPI Standard T 402 m. Determine the area of the specimen to the nearest 0.5% of its total area, i.e., measure its dimensions to within 0.25%. Determine the weight of the specimen or specimens to the nearest 0.25% of the total weight. Calculate the average weight in grams per square meter from the measured area of the specimens and their weight.

If the special sheet-weighing device is used, the dimensions of the sheets should be within 0.25% of the required size; otherwise, for accurate work, a correction must be applied.

REPORT

For paper, express the weight in grams per square meter to three significant figures and if desired, the equivalent weight for the ream size used by the paper industry for the particular kind of paper.

For paperboard, report the basis weight in grams per square meter or in pounds per 1000 sq. ft. or both, to three significant figures.

If the total area of the test specimen is less than that specified, state the actual area and number of the specimens tested.

ADDITIONAL INFORMATION

1. For weighing specimen sheets on a gram balance or on a paper scale:

If a = length of sample in inches,
or y = length of sample in centimeters;
b = width of sample in inches,
or z = width of sample in centimeters;
g = weight in grams of sheets weighed,
or p = indicated weight on scale for 500-sheet ream;
and
n = number of sheets weighed;
then the weight in grams per square meter is given by:

$$\frac{1550\ g}{abn} \text{ or } \frac{10{,}000\ g}{yzn} \text{ or } \frac{1406\ p}{abn} \text{ or } \frac{9070\ p}{yzn}$$

To within less than 0.5%, grams per square meter is numerically equivalent to pounds (35 × 40—500).

* This proposed revision will be voted upon by the membership of TAPPI; minor changes may be made before publication in loose-leaf form.

2. In the following table conversion factors are given for converting the weights of some customary trade sizes of 500-sheet reams (t) and grams per square meter (m):

Table I. Ream Weight Conversion Factors

	t in.	A	B
Kind of paper	Trade Size	(m to t)	(t to m)
Writing & printing	17 × 22	0.266	3.760
(Demy size)	17½ × 22½	0.280	3.571
Blotting	19 × 24	0.324	3.083
Cover	20 × 26	0.370	2.704
Tissue (double crown size)	20 × 30	0.427	2.343
Cardboard	22 × 28	0.438	2.282
Bristol & tag	22½ × 28½	0.456	2.195
News & wrapping	24 × 36	0.614	1.627
Book	25 × 38	0.675	1.480
(Former TAPPI Standard size)	25 × 40	0.711	1.406
Paperboard	1000 sq. ft.	0.205	4.881

In Table I:

A = 0.711 × (area of trade size sheet in square inches ÷ 1000)
B = 1406 ÷ (area of trade size sheet in square inches)

If the given trade size is in 480 sheets, then the above factor A is multiplied by 48/50 (or 0.960) and B by 50/48 (or 1.042) for conversion.

Examples:

Grams per square meter × A = pounds weight of given trade size: e.g., 60 g.s.m. × 0.614 = 36.8 lb. (24 × 36—500).

Pounds weight of given trade size × B = grams per square meter: e.g., 50 lb. (25 × 38—500) × 1.480 = 74 g.s.m.

3. This revision withdraws the former TAPPI Standard size of (25 × 40—500) and in its place substitutes grams per square meter (g.s.m.) as the sole TAPPI Standard unit for the basis weight of paper and also recommends it as an alternative for paperboard. It is, of course, permissible to state the basis weight of paper in any desired form in parentheses following its statement in grams per square meter.

The tolerance for the determination of the area of the specimen also has been broadened.

4. Related Methods: ASTM, D646; CPPA Tech. Sect., D-3; APPITA, P405m; B.P.B.M.A., PT4; VZ & PCI, V/11. All recognize grams per square meter as a standard unit of basis weight.

Physical Testing of Pulp Handsheets

*Proposed Revision of Tappi Standard T 220 m-53**

(THIS STANDARD IS UNDER THE JURISDICTION OF THE PULP TESTING COMMITTEE)

This procedure deals with the testing of pulp handsheets, prepared in accordance with TAPPI Standard T 205 m, for strength and other physical properties, excepting optical properties for which see T 218 m.

Five sheets are generally enough for all the usual tests. It is well, however, to prepare six sheets and attach one to the report.

PROCEDURE

Dry the sheets to constant weight and test them in an atmosphere maintained at 50 ± 2% R.H. and a temperature of 23 ± 2°C. (73 ± 3.5°F.)

Test the sheets for each characteristic according to the appropriate TAPPI Standard paper testing method, with deviations as specified below.

A convenient method of dividing and using five test sheets for making the usual tests is shown in Fig. 1.

BASIS WEIGHT

Determine the average basis weight of the conditioned sheets by weighing them together on a balance sensitive to 0.01 g.

The area of each sheet (6 $^{9}/_{32}$ in. diam.) is taken to be 200 sq. cm. Hence if n is the number of sheets in a group weighing w grams, the basis weight is 50 w/n g.s.m., conditioned basis. The moisture-free basis weight is obtained by multiplying this value by the dryness factor z/y (see Moisture below).

THICKNESS

Before cutting the test sheets, obtain their average thickness by placing five sheets in a pile with their glazed surfaces in the same direction and measuring the thickness of the five sheets together. Use a micrometer having a pressure foot 14.3 to 16.5 mm. in diameter, and a closing pressure of 0.52 ± 0.03 kg. per

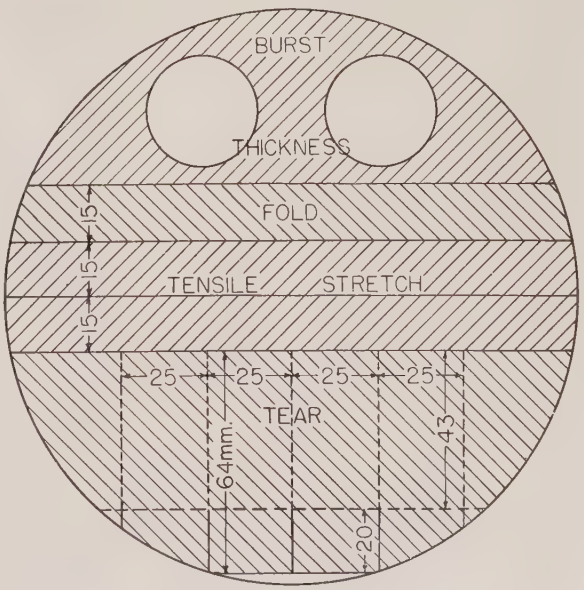

Fig. 1. Division of sheet for testing

It is recommended that the length of the strip for tearing strength 47 cm. instead of 43 cm. (*See* Note under Tearing Strength)

* This further revision of that published in *Tappi* in September, 1958, will be voted upon by the membership of TAPPI. Minor changes may be made before publication in loose-leaf form.

sq. cm. If a motor-driven micrometer is not available, apply the pressure slowly and gently, then rap the gage gently with the tips of the fingers and take the reading after the needle ceases to move. Take five readings to the nearest 0.0001 in., one from the center of the pile, and four symmetrically around the sheets, halfway between the center and the edge. Calculate the average thickness of a single sheet to three significant figures.

Note: To obtain an accurate figure for average sheet thickness from which to calculate the property of Standard Test Sheet Density (or Bulk), which may be used as a basis for plotting results, the described procedure should be carefully and systematically followed. It is not the same as described in T 426 m but conforms with the original specification for testing pulp sheets.

TENSILE STRENGTH AND STRETCH

Use at least ten strips from five test sheets, each strip cut 15 mm. wide. Set the jaws of the tensile tester (see TAPPI Standard T 404 m), 90 to 100 mm. apart and increase the load uniformly at the rate of 1 ± 0.3 lb. (0.45 ± 0.15 kg.) per sec. until fracture occurs. If the breaking load is less than 4 lb. (1.8 kg.), decrease the rate of loading so that fracture occurs in 5 ± 1 sec.

Note: This is a rate different from that specified in T 404 m and conforms with the original specification for testing pulp test sheets.

If the stretch is measured, watch the indicator continuously during the test, and if it jumps when the specimen breaks, record the reading immediately before the jump.

Note: It is convenient to align and clamp the ends of all the strips together in the upper jaws of the tensile tester and successively insert and clamp the lower ends, one at a time, in the lower jaws to break them individually.

BURSTING STRENGTH

Determine the bursting strength one at a time by making at least ten bursts on the segments of five test sheets, the glazed side of each sheet being clamped toward the diaphragm; otherwise, in accordance with TAPPI Standard T 403 m.

TEARING STRENGTH

Determine the tearing strength on a 16-sheet standard tearing tester as described in TAPPI Standard T 414 m except that, if the readings fall outside of the limits, the instrument should be carefully calculated accordingly. Clamp the sheets so that their smooth sides face the axis of the instrument and the greater part of the specimen is held in the fixed, not the moving, jaw. With chemical pulps, divide portions from five test sheets in the manner shown in Fig. 1 and test the five portions together, making four tears, each being through a total tearing distance of 21.5 cm. (5 × 4.3). Multiply the average reading on the standard tear tester by 3.2 (i.e., 16/5) to obtain the force in grams required to tear a single sheet.

Note: Accuracy and convenience will be enhanced, especially if the segment of sheets was cut somewhat narrow, if a template is made to draw a pencil line 47.0 mm. from the centrally cut edges of the pack of specimens. When they are clamped in the jaws of the instrument, align the pack so that the scribed line coincides with the top edges of the jaws. The knife should be checked to cut 4.0 mm. above these edges, to give a tearing distance of 43.0 mm.

For groundwood pulps, use ten quadrant-shaped pieces from five test sheets, each piece half the area used for the tear; test as shown in Fig. 1. Make three, possibly four, tears, each through a total tearing distance of 43 cm. (10 × 4.3). Multiply the reading of the instrument by 1.6 (i.e., 16/10) to obtain the force in grams required to tear a single sheet. If ten sheets are used for weak pulps other than groundwood, state this in the report.

If the specimens should be such that five sheets together give too high a reading, reduce the number of sheets torn together to two and multiply the observed reading by 8 to give the force in grams to tear a single sheet.

MOISTURE

When the tests are completed, collect about 2 g. of the scraps of any of the test sheets, weigh them (y g.), place in an oven at 105 ± 3°C. in an uncovered weighing bottle which has been previously dried and weighed with its cover, and dry until no further loss of weight occurs. Between weighings, place the covered bottle in a desiccator without removing the stopper, let it cool, open momentarily to let in the air, close it immediately, and weigh to determine the dry weight of the scraps (z g.).

Note: The cover is used while cooling since the desiccating effect of the pulp may be greater than that of the desiccant used.

The percentage moisture content of the sheets under standard atmospheric condition is then: $(y - z)/y$. The moisture-free basis weight, in gsm., is: $50\ wz/ny$. (See under Basis Weight, above.)

Note: For the same kinds of pulp, if the humidity room is kept constant, the moisture contents will not vary appreciably and once established, for routine control work, these need be checked only occasionally. Air-dried chemical pulps normally contain less moisture than groundwood, and rag or purified pulps, still less.

OTHER TESTS

If desired, other tests, such as zero-span tensile, folding endurance, porosity (air pressure applied to the glazed side of the sheets), stiffness, etc., may be made according to standard procedures.

REPORT

Report results in terms of their derived units to the nearest third significant figure. If the direct test results, i.e., the actual instrument readings are reported, either (1) metric or (2) English units may be used as is common practice, the unit being stated in each case. For derived units, however, such as the various strength factors, only the metric system is standard; with all the results, except the percentage of moisture, being calculated and reported on the moisture-free basis weight of the test sheets.

The calculations of the various items reported are shown below by formulas in which:

r = basis weight in grams per square meter (moisture-free basis)
t = single sheet thickness in thousandths of a millimeter (microns)
T = single sheet thickness in thousandths of an inch
b = bursting strength in grams per square centimeter
B = bursting strength in pounds per square inch
p = tensile break load in kilograms on a 15-mm. strip
P = tensile break load in pounds on a 15-mm. strip
e = force in grams to tear a single sheet

Note: $t = 25.4T$; $b = 70.3B$.

Basis Weight: In grams per square meter (moisture-free basis).

Moisture: As a percentage of the air-dried (conditioned) weight.

Bulk (specific volume): Calculated as cubic centimeters per gram from t/r or $25.4T/r$.

Density (specific gravity): The reciprocal of bulk.

Note: The result compares the density or bulk of the test sheets (measured under the prescribed pressure) to water, which has a bulk or density of 1.0.

Burst Factor: From the formula b/r, or $70.3B/r$.

Note: This factor, which has been called the "bursting area," is equivalent to the number of square centimeters of paper, the weight of which, if applied to each square centimeters of the test sheet clamped in the instrument, would cause a burst.

Breaking Length: In meters, calculated from the formula

$$\frac{200{,}000\ p}{3r} \text{ or } \frac{30{,}240\ P}{\text{r}}$$

Note: This is equivalent to the length in meters of a uniformly wide strip of paper which, if held at one end (e.g., freely suspending a coil of that paper by its tab end), would just cause the strip to break under its own weight.

Stretch: As a percentage.

Tear Factor: From the formula $100e/r$.

Note: This factor, which has been called the "tearing area," is equivalent to the number of square decimeters (100 sq. dm. = 1 sq. m.) of paper, the weight of which, if applied to a single sheet, would cause a tear to progress.

PRECISION

Repeatability: If the average basis weight of the test sheet is kept within 57 to 63 g.s.m. as specified, on a complete duplicate test for a set of handsheets made from one sample of pulp by one operator, the repeatability of the average burst factor may be expected to be within 2% or less, depending on the precision of the instrument.

Reproducibility: In tests on a given shipment by different laboratories, if the paper testing instruments are standardized, the following maximum differences may be expected in the averages: burst factor, 5%; breaking length, 7%; tear factor, 10%; bulk, 5%. These are about the same as for paper testing.

Note: These percentages have not been checked by a comprehensive statistical analysis. Much wider discrepancies may be introduced if the test sheets are made from pulp samples which have been separately beaten, especially if not with the same equipment. Furthermore, accuracy may be expected only if all the testing equipment is carefully standardized and the procedures meticulously followed.

ADDITIONAL INFORMATION

This revision of T 220 m-53 clarifies the drying and conditioning of the test sheets, specifies the measurement of their thickness and tear in greater detail, and emphasizes that the derived test results are reported in metric units only and on a moisture-free basis, in accordance with now almost worldwide practice.

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Recommended Voltage Levels for A. C. Polyphase Motors

TAPPI Data Sheet 209

THIS DATA SHEET UNDER THE JURISDICTION OF THE ELECTRICAL ENGINEERING COMMITTEE

Table I provides a listing of the minimum size motor *recommended* for a given system voltage together with the minimum size motor permissible on a given system voltage.

Table I. Minimum Horsepower Rating Versus Terminal Voltage

Either Synchronous, Squirrel Cage, or Wound Rotor Motors Unless Otherwise Noted

Terminal voltage, volts	*Motor speeds, r.p.m.*	*Recommended minimum horsepower*	*Minimum permissible horsepower*[a]
600 or below	All speeds	1	. . .
601– 3,000	3600	200	60
601– 3,000	1800 or less	150	40
3001– 5,000	3600	350	200
3001– 5,000	1800 or less	300	150
5001– 7,000	3600	1000	300
5001– 7,000	1800 or less	800	250
7001–13,200	3600 induction	[b]	[b]
7001–13,200	1800 and 1200 induction	5000	[b]
7001–13,200	900 or less induction	3000	[b]
7001–13,200	3600 synchronous	2500	[b]
7001–13,200	1800 or less synchronous	2000	[b]

[a] The minimum permissible horsepower is the approximate minimum size that motor manufacturers are willing to build.
Motors of this size are limited in mechanical coil strength. Motors below the *recommended* minimum horsepower should be used only where mill conditions make such motor selection imperative.

[b] Thirty-six hundred revolutions per minute induction motors of this voltage classification can be built. Slower speed induction motors and the synchronous motors of lower horsepower than recommended can also be built. Such motors, however, are limited in the mechanical strength of the stator winding and lower voltage designs provide economic benefits as well as improved construction.

Table II tabulates economical motor horsepower versus terminal voltage relationships for various voltage levels of mill generation and distribution.

Information in Table II is based upon general economic conditions and includes the comparative costs of controls, transformer capacity, etc. (cable costs are not included and must be considered in final evaluation).

Table II. Suggested Voltage-Motor Horsepower Relationships for Various Mill Generation and Distribution Voltage Levels Based Upon Overall Economic Factors

The Overlap in Suggested Horsepower Takes Into Account the Wide Variation in Individual Installations

Primary mill distribution voltage, volts	*Motor design voltage*			
	600 v. or below	*2300 v.*	*4000 v.*	*6600 or 13,200 v.*
2400	1–400 hp.	150–3500 hp.	. . .	. . .
4160	1–400 hp.	. . .	250–6000 hp.	. . .
6900 (if no intermediate voltage; not usual practice)	1–1250 hp.	. . .	. . .	800–10,000 hp.
6900 (if 2400 volt intermediate voltage)	1–400 hp.	150–3500 hp.		1000–10,000 hp.
13,800	1–400 hp.	150–3500 hp.		3500–10,000 hp.

Example: A 250-hp., 1200 r.p.m. motor is to be applied in a mill where the distribution voltage is 4160 v. and the secondary mill voltage is 480 v. Table I indicates that 480 v. is the preferred voltage from a design standpoint. Table II indicates that the 480-v. level is economically sound.

This estimating data compiled by the Electrical Engineering Committee is based upon mill experience and manufacturing recommendations. Revised 7-18-60. Originally proposed 8-15-57.

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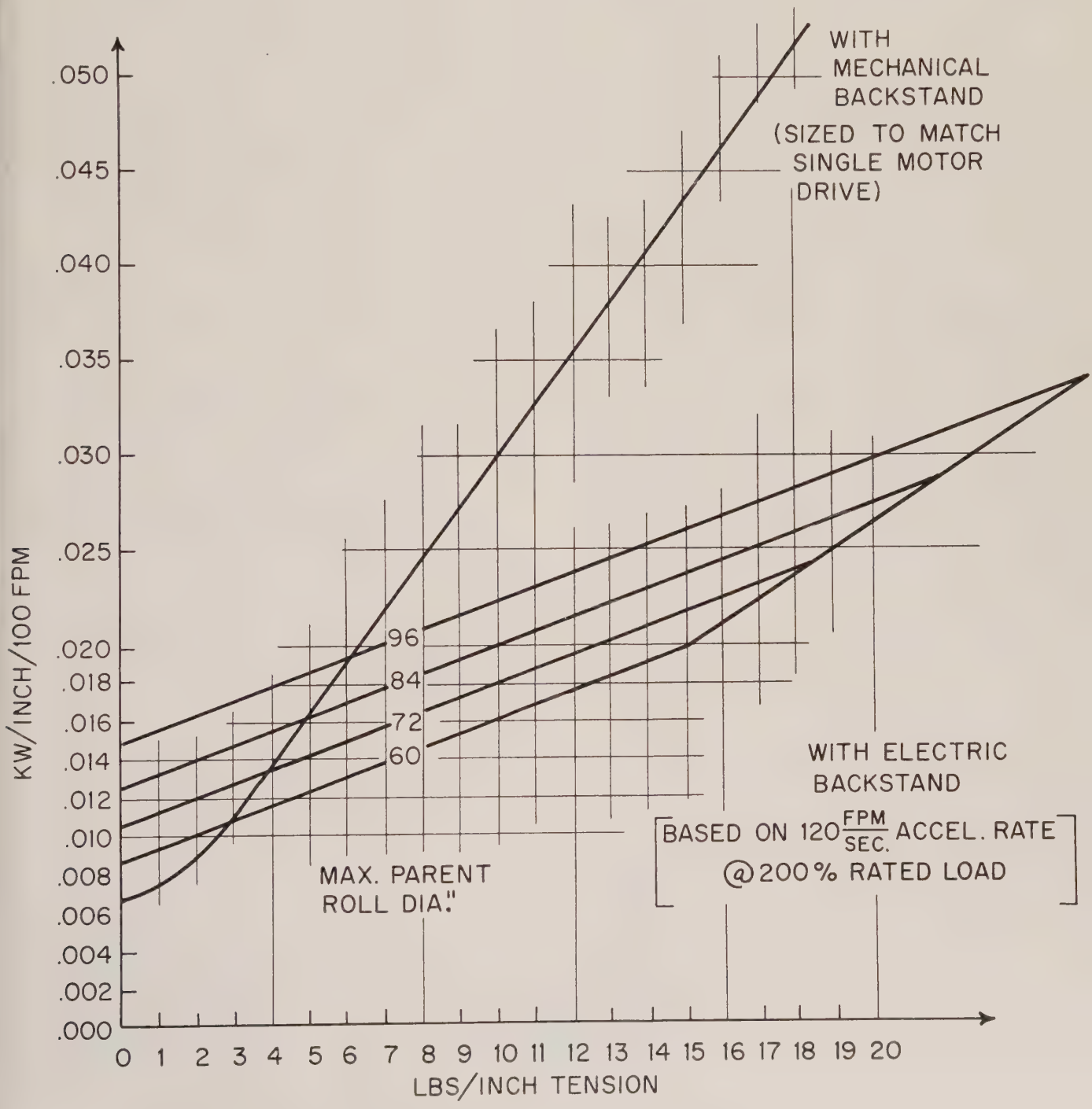
Power Requirements for Paper Machines

Winder Generator Power (kw.) Requirements

TAPPI Data Sheet 208

THIS DATA SHEET UNDER THE JURISDICTION OF THE ELECTRICAL ENGINEERING COMMITTEE



RC-288. Formation in Paper

The purpose of this method is to provide a means of comparing the formation in a sheet of paper to a sample which has satisfactory formation.

Equipment

The testing equipment required consists of a formation tester and a sample cutter.

Calibrating the Instrument

Place the two units of the formation tester on a sturdy bench free from vibration. Place the scanning unit to the left and the amplifying unit to the right. Raise the main lid of the scanning unit. Remove the tape holding the moving parts. Turn the disk clockwise and be sure that everything is moving freely. Lower the lid. Make two plug connections between cabinets. Plug in the 110 v., 60 cycle a.c. To test the light source, turn the pointer knob for the shutter to the closed position and turn on the light switch to make sure the light works.

Caution. It is a safe policy to keep the top cover closed while the motor switch is on because of the high speed of rotation of the disks.

Preparing the Sample

Cut a sample of paper with the sample cutter according to the manufacturer's directions.

To insert this sample, lift off the upper glass plate. Place the sample on the lower plate and replace the upper plate.

With the shutter closed turn on the light. The lamp should focus on the paper. If the image on the paper is not sharp, the Allen screw that holds the lamp holder in place may be loosened and the entire housing raised or lowered. Do not burn the lamp any longer than necessary as the bulb generates considerable heat.

Operating Procedure

1. Turn the power switch, amplifier switch, and null switch on.
2. Place a sample of an acceptable grade of paper with which the unknowns are to be compared on the lower glass disk. Then place the upper glass plate in position and close the top cover.
3. Open the shutter by turning pointer knob on front of scanning unit to the open position.
4. Start motor and turn on the light by means of the motor and light switches on the scanning unit panel.
5. For thin papers use high bias, and for heavier papers use low bias. The bias switch is located in the middle of the amplifier panel.
6. *Null Indicator.* When the needle is in the null position, it means that a standard light signal is reaching the photocell. To position the needle in the null position proceed as follows: depress push button and adjust rheostat knob to the left of the push button until the needle is in the null position. Release push button. With the coarse and fine adjust knobs below push button, adjust the needle to the null position. Make adjustments until the needle remains in the null position when push button is depressed.
7. Adjust ratio rheostats directly under ratio meter until ratio meter reads any desired value. It is suggested that you select one specimen to be regarded as a standard—against which all other specimens of the same type be checked. The ratio meter should then be set to a value of 1.0 for this standard.
8. Now shut off motor and light switches. Remove acceptable sample and replace it with an unknown sample.
9. Repeat steps 3, 5, and 7. Do not change position of ratio rheostats.
10. Read ratio meter.
11. Shut off motor and lamp switches.
12. When checking several samples against the acceptable sample, it is advisable to check with this sample after every fourth or fifth unknown.

Reporting

The formation number is one hundred times the meter reading. High formation numbers mean good formation and low ones mean poor formation.

Note: This instrument may be purchased from the Thwing-Albert Instrument Co., Philadelphia 44, Pa.

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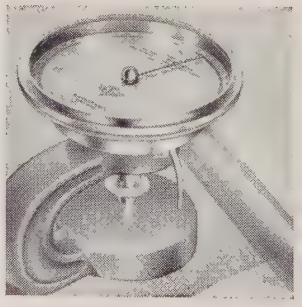

New Micrometer shown at left calipers to 10/1000 ths of an inch

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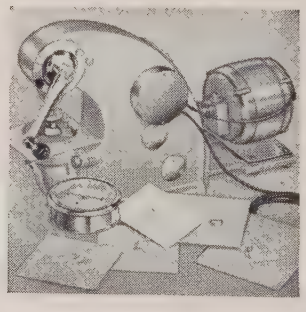


E. J. CADY & COMPANY • MANUFACTURERS • 638 NORTH HARLEM • RIVER FOREST, ILLINOIS

LOCAL SECTION ACTIVITIES

Meeting Calendar

December, 1960

2 Central District, Empire State Section, University Club, Syracuse, N. Y. "Nip Impressions, by a representative of Stowe-Woodward Co.

2–3 Gulf Coast Section, Miss.

5 New England Section, Storrowton Tavern, West Springfield, Mass.

8 Northern District, Empire State Section, Hotel Woodruff, Watertown, N. Y. Students' Night. Speaker: P. E. Nethercut.

9 Delaware Valley Section, Engineers Club, Philadelphia, Pa. "Stock Cleaning."

13 Metropolitan District, Empire State Section, 465 Lexington Ave., New York, N. Y. "Dyeing of Paper," by Joseph Gessner, Head of Paper Division, E. I. du Pont de Nemours & Co. Inc.

15 Ohio Section, Manchester Hotel, Middletown, Ohio. "Plastic Fourdrinier Wires," by Charles Lee, Formex Co.

20 Indiana District, Ohio Section, Marott Hotel, Indianapolis, Ind. "Plastic Printing Plates."

January, 1961

6 Central District, Empire State Section, University Club, Syracuse, N. Y. "General Coating Methods," by George Booth, Black-Clawson Co.

9 Eastern District, New England Section, Armand's Beacon Terrace, Framingham, Mass.

10 Metropolitan District, Empire State Section, 465 Lexington Ave., New York, N. Y. "State of the Industry," by W. R. Adams, President, St. Regis Paper Co.

10 Ohio Section, Manchester Hotel, Middletown, Ohio. "Some Recent Advances in Interfiber Bonding with Wet End Additives," by Merchant L. Cushing, A. E. Staley Mfg. Co.

10 Berkshire District, New England Section, Pittsfield Country Club, Pittsfield, Mass. "The Nature of Pulps."

12 Northern District, Empire State Section, Hotel Woodruff, Watertown, N. Y. "Problems in Research and Development for Small Specialty Mills," by F. C. Keeney.

17 Pacific Section, Tacoma, Wash., "Process and Quality Control Techniques."

20–21 Southeastern Section, Francis Marion Hotel, Charleston, S. C.

26 Delaware Valley Section, Engineer Club, Philadelphia Pa., "Packaging."

February, 1961

3 Central District, Empire State Section, University Club, Syracuse, N. Y. "Natural Resources of New York State as Related to the Pulp & Paper Industry," by Assemblyman R. W. Pomeroy and N. J. Stout.

9 Ohio Section, Manchester Hotel, Middletown, Ohio. "Trailing Blade Coating," by Harold Annis, Oxford Paper Co.

Northern District Empire State Section, Hotel Woodruff, Watertown.

March, 1961

2 Lake Erie Section, Cleveland, Ohio.

3 Central District, Empire State Section, University Club, Syracuse, N. Y. "New Developments in Corrugated Boxes," by Patrick Palmaccio, Mead Corp.

9 Northern District Empire State Section, Hotel Woodruff, Watertown.

13 Eastern District, New England Section, Armand's Beacon Terrace, Framingham, Mass.

14 Metropolitan District, Empire State Section, 465 Lexington Ave., New York, N. Y. "The Paper Industry in Europe," by A. W. Wilson, Editor, *Pulp & Paper*.

14 Ohio Section, University Center, Miami University, Oxford Ohio. "Appearance Properties of Paper," by Richard Hunter, Hunter Associates Laboratory.

21 Pacific Section, Longview, Wash., Shibley Award Meeting.

24–25 Southeastern Section, Bon Air Hotel, Augusta, Ga. Tour of Continental Can Co.

April, 1961

6 Lake Erie Section, Cleveland, Ohio.

7 Central District, Empire State Section, University Club, Syracuse, N. Y. Senior Night—Junior Awards.

10 New England Section, Storrowton Tavern, West Springfield, Mass. Management Night.

11 Metropolitan District, Empire State Section, 465 Lexington Ave., New York, N. Y. "The Reused Fiber."

13 Ohio Section. Tour National Cash Register Co. at Dayton, Ohio.

13 Northern District, Empire State Section, Hotel Woodruff, Watertown, N. Y. Joint meeting with Beaver Falls Chapter, A.I.C. "The Planning of a Technical Center," by K. A. Arnold, St. Regis Paper Co.

May, 1961

4–6 Pacific Section, Harrison Hot Springs, Tri-Way Convention.

11 Northern District Empire State Section, Hotel Woodruff, Watertown. Annual Ladies' Night.

11 Ohio Section, Hartwell Recreation Hall, Cincinnati, Ohio. Ladies' Night.

19 Metropolitan District, Empire State Section, Tavern-on-the-Green, New York, N. Y. Ladies Night.

19–20 Southeastern Section, General Oglethorpe Hotel, Savannah, Ga.

June, 1961

8–10 Empire State Section, Whiteface Inn, Whiteface, N. Y.

9–10 Joint Meeting, New England Section and Maine-New Hampshire Section, Wentworth-by-the-Sea, N. H.

June, 1962

1–2 New England Section, Chatham Bars Inn, Chatham, Mass.

7–9 Empire State Section, Whiteface Inn, Whiteface, N. Y.

June, 1963

6–8 Empire State Section, Whiteface Inn, Whiteface, N. Y.

A Power Factor Study Using Existing Metering

E. E. EGAN

An actual paper mill power distribution system is used as an example to show how a power factor study can be made without the use of temporary metering. A close examination of the connected loads, supplemented by existing meter information provides ample data to give approximate results. The results are sufficiently accurate to permit valuable observations about the system involved.

In most large industrial power contracts a power factor clause is included which penalizes the user if the power factor is below a certain level. These penalties are justified by the utility's additional cost of service at low power factor. Avoidance of these penalties is the main reason industrial plants are interested in power factor.

Much has been written about power factor in some form or another and perhaps it would be wise to tell the purpose of this paper at the beginning. It is not the intent of this paper to describe why or how to correct power factor since there are many excellent papers and books on the subject already. The purpose of this paper is to describe various methods for making a power factor study without purchasing and connecting extra meters to an existing system.

Before proceeding with how this can be done, perhaps it would be well to review what power factor is. From the Standard Handbook for Electrical Engineers, ninth edition, power factor is defined as follows: "The power factor of a circuit is the ratio of true power in watts, as measured with a wattmeter, to the apparent power obtained from the product of the current and the potential, in amperes and volts, respectively. In a.c. circuits, the power factor is usually less than unity because the current and potential are not in phase. When the waveform is sinusoidal, the power factor is equal to the cosine of the phase angle." For a balanced three phase circuit the items mentioned above are stated mathematically in formulas (1), (2), and (3) of Table I. These relationships are shown vectorially in Fig. 1. The quadrature component is referred to as reactive volt-amperes and has been shortened to "Var" (KVAR or kilo-vars is more frequently used). From this brief review it becomes obvious that in order to determine the power factor of a circuit it is necessary to know the volts, amps, and watts of the circuit. To obtain these items the ideal condition would be to have a voltmeter, ammeter, and wattmeter at each point of load distribution. However, in practice frequently only one or two of the three items necessary to determine power factor are readily obtained from existing meters. This would not be objectionable if meters could be temporarily installed but this would require a shutdown and many industrial plants demand uninterruptable power so that it is practically impossible to get meter readings except only at the lower voltage levels. To further complicate the matter some systems are so large that the time required to complete a power factor study would be far too long if meters had to be moved from one spot to the next whenever shutdowns occurred. So the thing we are faced with is getting the necessary information from what meters do exist and the rest by other methods.

E. E. Egan, Senior Electrical Engineer, Camas Div., Crown Zellerbach Corp., Camas, Wash.

METHODS FOR DETERMINING MILL POWER FACTORS

The most valuable tool in preparing a power factor study is an accurate one line diagram showing main power flow and all existing metering including watt-hour meters. This diagram should make no attempt to show relative location of equipment since this would tend to cloud the relationship of one part of a distribution system to another.

After the one line diagram has been prepared, a close examination of the existing voltmeters, ammeters, and wattmeters will establish the areas that require different methods for determining power factor.

The most valuable source for additional information are watt hour meters. Figure 2 shows a typical watt hour meter with the glass cover removed. Such meters are designed to register energy which is merely power per unit time. These meters are generally of the induction type wherein a metallic disk is made free to rotate between magnetized poles, much like an induction motor. The rotating disk drives a gear chain which operates a registering mechanism on which the energy consumption is indicated. The speed at which the disk rotates is a measure of power. The energy represented by one revolution has been determined by the manufacture and is marked on the meter. This is called the watt hour constant and is designated by the symbol K_h. Generally the watt hour constant will be stamped on the nameplate or painted on the disk itself. The indicated watthours will be K_h times the number of revolutions of the disk. To convert energy (watt-hours) to power (watts), formula (4) in Table I is used.

Instrument transformers must always be taken into account when using formula (4) and also dividing by 1000 obtains kilowatts (kw) which is the more conventional form. Revising formula (4) gives us formula (5).

Using formula (5) we can now obtain the power in a circuit merely by taking a stop watch and counting the number of disk revolutions for any given time interval.

Approximate Methods

After exhausting all sources of information obtainable from existing meters several schemes for approximating the power factor can be used. These methods are somewhat tedious but not very difficult to perform. The first is an

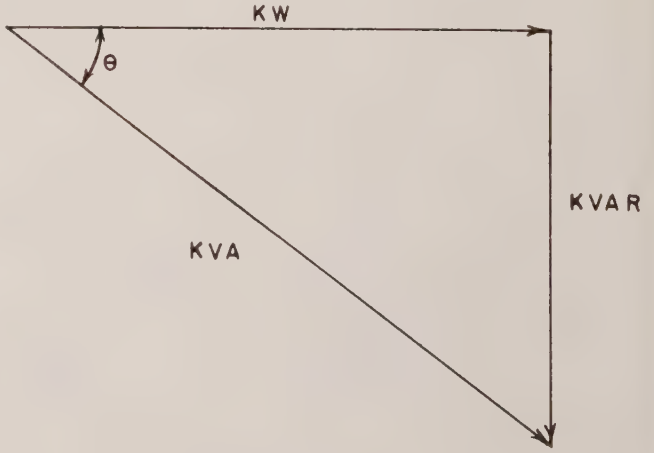


Fig. 1. Vector relationship between real power (kw.) and apparent power (kva.)

Table I. Formula for Determining Power Factor

(1) Kw. $= \frac{\sqrt{3}\ EI\ \text{Cos}}{1000}\ \theta$ (kilowatts)

(2) Kva. $= \frac{\sqrt{3}\ EI}{1000}$ (kilovolt-amp.)

(3) P.F. $= \frac{\text{kw.}}{\text{kva.}} = \text{Cos}\ \theta$

(4) W $= \frac{3600 \times R \times K_h}{S}$

(5) Kw. $= \frac{3600 \times R \times K_h \times PT \times CT}{1000\ S}$

$= \frac{3.6R \times K_h \times PT \times CT}{S}$

(6) Kva. $= \frac{\text{Connected hp.} \times 746 \times \text{demand factor}}{1000 \times \text{P.F.} \times \text{efficiency}}$

where

K_h	=	watt hour constant
R	=	revolutions of disk
S	=	time in seconds
PT	=	potential transformer ratio
CT	=	current transformer ratio
w	=	watts
E	=	line voltage
I	=	line current
kva.	=	kilovolt—amperes
kw.	=	kilowatts
h.p.	=	horsepower
P.F.	=	power factor

examination of the type of loads connected to a particular circuit. Is it all lighting, or motors or both? If it is all motors, what type of motors—squirrel cage or synchronous? Are there any capacitors used for power factor correction? While examining the type of load on the circuit it will be necessary to get an actual count of the number and size of lights, motors, and any other type of load.

If the load is all lighting the power factor can be assumed to be very nearly unity unless it is known that fluorescent or mercury vapor lights are used without power factor correcting ballasts. Uncorrected ballasts have power factors of about 50%. Corrected ballasts have power factors of over 90%.

If the load is all squirrel cage motors it will be necessary to consider the demand factor of the process involved. Demand factor is defined as the ratio of actual demand to total connected load. This is particularly true if the process has motors with varying degrees of intermittent service. Also the installed motor capacity is frequently oversized which results in a low demand factor. Oversized motors also effect the power factor and efficiency of the motor. For example, a motor that is only 50% loaded will have a power factor and efficiency of about 80% (fully loaded motors would be about 90%). The approximate kva. of a load consisting entirely of squirrel cage motors is given in formula (6) in Table I. Demand factors for pulp and paper mills range from 50 to 80%, depending on the process involved.

When the load consists of synchronous motors, it is difficult to predict what power factor exists since this is affected by both load and excitation. About the best that can be done is to make an "educated guess" based on name plate data and personal experience with the particular loads involved. One thing to keep in mind is the fact that a synchronous motor running with a leading power factor at full load will go more leading with light load if the excitation is held constant.

Vector diagrams are another valuable aid in making a power factor study in that they provide a method for obtaining load information about circuits that cannot be solved any other way. This is particularly true when a single bus feeds multiple loads of which one or two have little or no metering at all. The technique involved in to construct a vector diagram with the data provided from metered loads. The resulting diagram will be incomplete and the vector that is drawn in to close the diagram will represent the magnitude and power factor of the unmetered load. Complex quantities can be substituted for vector diagrams and the circuits solved mathematically but then the solution may not be as easily visualized.

APPLICATION OF VARIOUS METHODS TO AN ACTUAL DISTRIBUTION SYSTEM

After discussing several methods for determining power factor let us now apply these methods to an actual system. The first step is to prepare a one-line diagram of the system involved. Figure 3 shows the primary distribution system for the Camas mill. You will note that main power flow is shown by the heavy lines from top to bottom. Emergency lines that are normally out of service are shown with light lines. At first glance the system appears to have plenty of metering, but a closer examination shows that there are several spots that will require the use of the methods already described. For example, no. 2 substation, and the kraft screen room roof switch center have no composite meters at all.

After all meters are located, the next step is to make several rapid tours around the system, recording the meter readings of all major points of load division. The average reading at each point should be tabulated. Table II shows the tabulated values for the Camas system. With these data we can now proceed step by step and determine the loads and power factors for the complete system. The computations are as follows (item numbers refer to Table II):

No. 1 Substation

No. 1 Bank

Kva. $= \sqrt{3}\ \frac{1283 \times 2350}{1000} = 5220$ (item 2)

Kw. = Sum of items 3 through 8

$= 3355$

P.F. $= \frac{\text{kw.}}{\text{kva.}} = \frac{3355}{5220} = 0.644$ lag

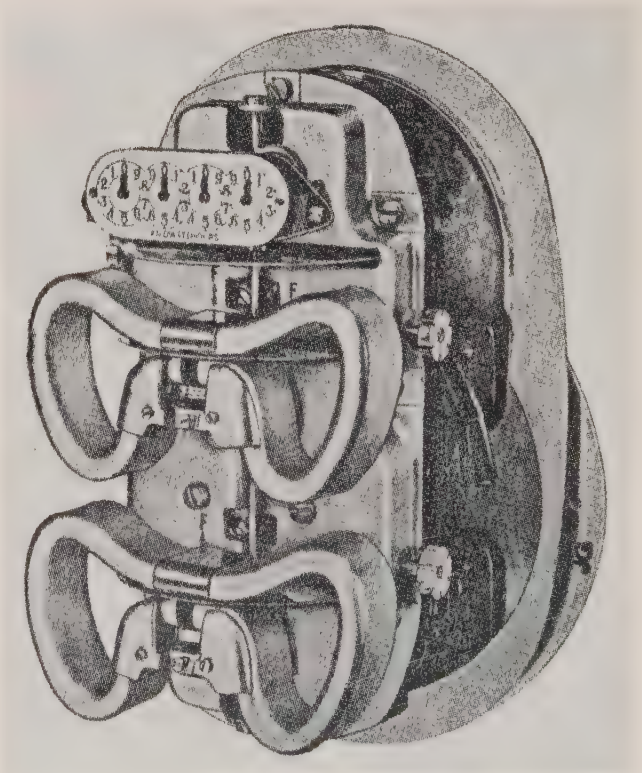


Fig. 2. Typical wat thour meter with glass cover removed

Table II. Major Load Distribution for Camas System

Item	Location	Meter readings
1	Purchased power from utility	34000 kw. at P.F. of 93% lag
2	No. 1 substation no. 1 bank sw no. 1	1283 a., 2350 v.
3	No. 1 substation no. 1 bank sw no. 3	900 kw.
4	No. 1 substation no. 1 bank sw no. 4	125 kw.
5	No. 1 substation no. 1 bank sw no. 5	1350 kw.
6	No. 1 substation no. 1 bank sw no. 8	850 kw.
7	No. 1 substation no. 1 bank sw no. 9	100 kw.
8	No. 1 substation no. 1 bank sw no. 10	30 kw.
9	No. 1 substation no. 2 bank sw no. 2	925 amp.
10	No. 4 switch room switch no. 7	3850 kw.
11	No. 1 substation switch no. P 13	60 amp.
12	No. 4 switch room switch no. 16	5000 kw.
13	No. 1 substation switch no. P 14	49 amp.
14	No. 4 switch room switch no. 23	R = 10, S = 66, K_h = 0.625 PT 20:1 CT 800:1
15	No. 5 substation 12000 kva. bank sw no. 2	7.2 kv., 340 amp., 2500 kw.
16	No. 5 substation 6000 kva. bank sw no. 1	2.37 kv., 1320 amp., 5300 kw.
17	Kraft screen room roof sw no. 1	190 amp., 1500 KVAR
18	Kraft screen room roof sw no. 1	0
19	Kraft screen room roof sw no. 3	120 amp.
20	Kraft screen room roof sw no. 4	65 amp.
21	Kraft screen room roof sw no. 5	65 amp.
22	Kraft screen room roof sw no. 6	175 amp.
23	No. 3 Substation switch no. 1	375 amp., 1250 kw.
24	No. 3 Substation switch no. 2	210 amp.
25	No. 3 Substation switch no. 3	310 amp.
26	Turbine room no. 1 or no. 2 gen.	2100 kw. at 89% lag
27	Turbine room no. 3 gen.	6800 kw. at 95% lag

The total connected horsepower on no. 1 bank is approximately 8400 which consists of about 80% squirrel cage motors at about 60% demand. Therefore we can assume the power factor is lagging.

No. 2 Bank

$$\text{Kva.} = \sqrt{3}\,\frac{2350 \times 925}{1000} = 3760 \text{ (item 9)}$$

$$\text{Kw.} = 3850 \text{ (item 10)}$$

$$\text{P.F.} = \frac{\text{kw.}}{\text{kva.}} = \frac{3850}{3760} = 1.02$$

Assume the power factor to be unity since greater than unity is not possible and is probably due to instrument error. A unity power factor is reasonable since the connected load on this bank consists of about 5000 hp. of squirrel cage motors, 2600 hp. of synchronous motors and a 1980 KVAR capacitor bank.

No. 3 Bank

$$\text{Kva.} = \sqrt{3}\,\frac{66{,}000 \times 60}{1000} = 6860 \text{ (item 11)}$$

$$\text{Kw.} = 5000 \text{ (item 12)}$$

$$\text{P.F.} = \frac{\text{kw.}}{\text{kva.}} = \frac{5000}{6860} = 0.73 \text{ lag}$$

No. 4 Bank

$$\text{Kva.} = \sqrt{3}\,\frac{66{,}000 \times 49}{1000} = 5600 \text{ (item 13)}$$

$$\text{Kw.} = \frac{3.6 \times R \times Kh \times PT \times CT}{S} = \frac{3.6 \times 10 \times .625 \times 16000}{66}$$

$$= 5450 \text{ (item 14)}$$

$$\text{P.F.} = \frac{\text{kw.}}{\text{kva.}} = \frac{5450}{5600} = 0.975 \text{ lag}$$

Numbers 3 and 4 banks are paralleled but have slightly mismatched internal impedances which accounts for the difference in load distribution. The connected load on the com-

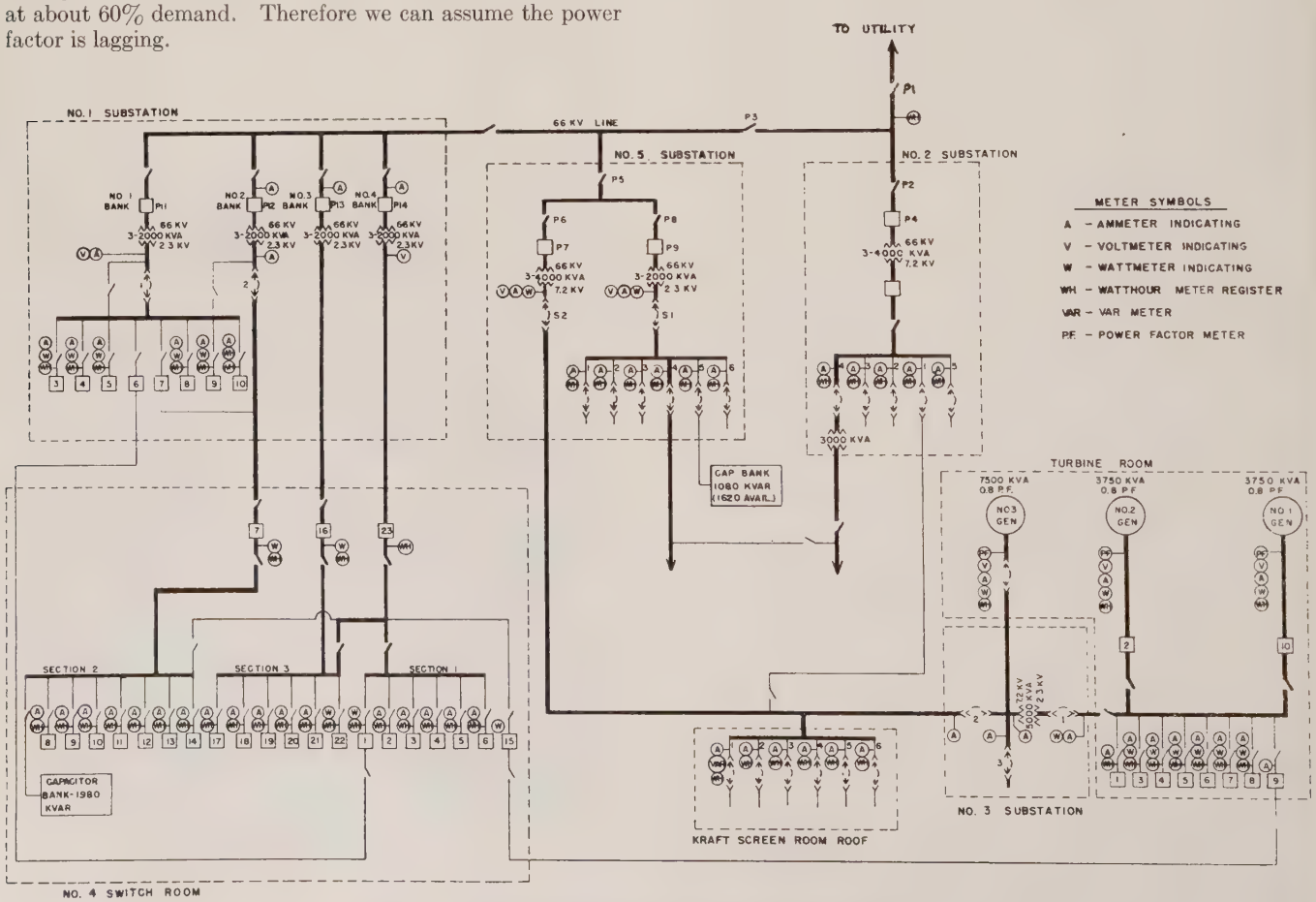
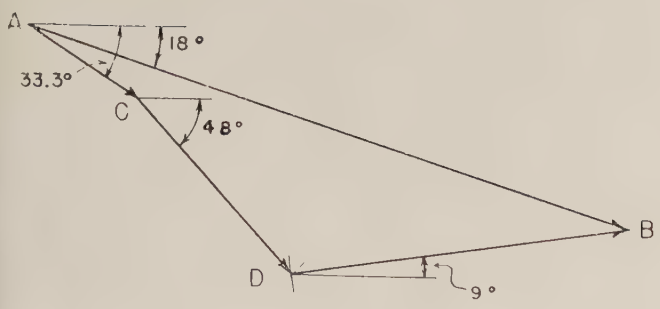
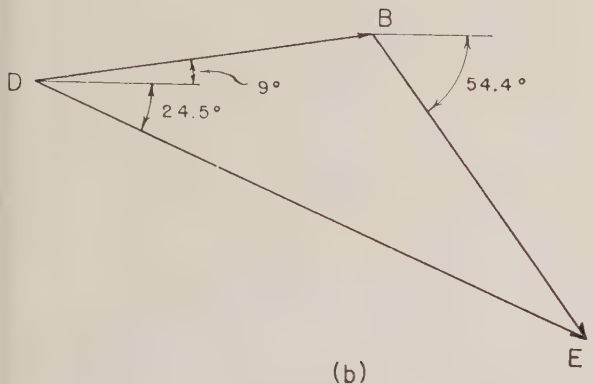


Fig. 3. One line diagram Camas distribution system



(a)



(b)

Fig. 4. Vector solutions for power factor angles

bined bus consists of about 7000 hp. in synchronous motors and about 12,000 hp. in squirrel cage motors so lagging power factor can be assumed for both banks.

Composite Load for No. 1 Substation

	P.F.	*Kw.*	*KVAR*
No. 1 bank	0.644 lag	3,355	4000
No. 2 bank	1.00	3,850	0
No. 3 bank	0.73 lag	5,000	3570
No. 4 bank	0.975 lag	5,450	1170
Totals		17,655	8740

$$\text{Tan } \theta = \frac{8740}{17655} = 0.495$$
$$\theta = 26.3$$
$$\text{Cos } \theta = 0.895 \text{ lag}$$

No. 5 Substation

12000 Kva Bank

$$\text{Kva.} = \sqrt{3}\,\frac{340 \times 7200}{1000} = 4290 \text{ (item 15)}$$
$$\text{Kw.} = 2500 \text{ (item 15)}$$
$$\text{P.F.} = \frac{2500}{4290} = 0.583 \text{ lag}$$

The basis for assuming a lagging power factor will be shown when the kraft screen room roof is analyzed.

6000 Kva Bank

$$\text{Kva.} = \sqrt{3}\,\frac{1320 \times 2375}{1000} = 5420 \text{ (item 16)}$$
$$\text{Kw.} = 5300 \text{ (item 16)}$$
$$\text{P.F.} = \frac{\text{kw.}}{\text{kva.}} = \frac{5300}{5420} = 0.977 \text{ lead}$$

The total connected horsepower on the 6000 kva. bank consists of about 5500 hp. in synchronous machines and 6700 hp. in squirrel cage motors plus a 1080 KVAR capacitor bank, therefore a leading power factor is reasonable.

Composite Load for No. 5 Substation

	P.F.	*Kw.*	*KVAR*
12,000 kva. bank	0.583 lag	2500	3485
6,000 kva. bank	0.977 lead	5300	1125
Total		7800	2360

$$\text{Tan } \theta = \frac{2360}{7800} = 0.302$$
$$\theta = 16.8°$$
$$\text{Cos } \theta = 0.957 \text{ lag}$$

No. 2 Substation

Combined loads of Nos. 1 and 5 substations

	Kw.	*KVAR*
No. 1 substation	17,655	8,740
No. 5 substation	7,800	2,360
Total	25,455	11,100

No. 2 Substation equals total purchased less Nos. 1 and 5 substations combined.

	Kw.	*KVAR*
From utility	34,000	13,400
No. 1 and No. 5	−25,455	−11,100
No. 2 sub (12000 kva. bank)	8,545	2,300

$$\text{Tan } \theta = \frac{2300}{8545} = 0.269$$
$$\theta = 15.10$$
$$\text{Cos } \theta = 0.963 \text{ lag}$$

Turbine Room

	P.F.	*Kw.*	*KVAR*
No. 1 or no. 2 generator	0.89 lag	2100	1070 (item 26)
Plus No. 1 sw at No. 3 sub.	0.836 lag	1250	820 (item 23)
Turbine room bus		3350	1890

$$\text{Tan } \theta = \frac{1890}{3350} = 0.565$$
$$\theta = 29.5$$
$$\text{Cos } \theta = 0.87$$

No. 3 Substation

Solution for no. 3 substation can be made easily by vector diagram shown in Fig. 4 (a).

AB = 575 amp. at 18° lag from 6000 kw. generator (item 27)
AC = 120 amp. at 33.3° lag to no. 1 switch (item 23)
CD = 210 amp. at 48° lag to no. 3 switch (item 25)
DB = 310 amp. at 9° lead to no. 2 switch (item 24)

Vector CD is assumed lagging because the load connected to switch No. 3 is all squirrel cage motors. Vectors CD and DB are constructed to close the diagram. The power factor angle is then measured with a protractor.

Kraft Screen Room Roof

Solution for kraft screen room roof is solved by vector diagram shown in Fig. 4 (b).

DB = 310 amp. at 9° lead from Fig. 4(a)
BE = 340 amp. at 54.4° lag from no. 5 substation (item 15)
DE = 550 amp. at 24.5° lag to kraft screen room roof

Vector DE is constructed to close the diagram and the power factor angle is measured with a protractor. The lagging power factor is reasonable because the major part of the load is squirrel cage motors. Also it becomes apparent that

the lagging power factor we assumed for the 12,000 kva. bank at No. 5 substation is verified since a leading power factor would give us unreasonable results.

From the results just obtained we can now make some comments about the distribution system. For example it would appear desirable to correct the poor power factor at no. 1 transformer bank at no. 1 substation. A closer look at the loads would probably suggest the best method to use. Also the 12,000 kva. transformer bank at no. 5 substation has a very poor power factor. An examination of Fig. 4 (a) suggests that by operating no. 3 generator at a more lagging power factor would improve the situation. This is so because vector DB in Fig. 4 (a) would have to become lagging and thus cause vector CD to become less lagging. With the exception of the two cases just mentioned the overall power factor is fairly good and any improvement would probably not be economically justified.

CONCLUSIONS

Using the methods and procedures described in this paper plus a liberal supplement of personal knowledge of equipment and operation of processes it is possible to make a power factor study of a distribution system without connecting additional meters to the system. It must be remembered that a study of this type is only approximate since the load is continually varying and also meters are frequently out of calibration.

LITERATURE CITED

1. Knowlton, A. E., "Standard Handbook for Electrical Engineers," Ninth Edition, McGraw-Hill.
2. Bailey-Gault, "Alternating Current Machinery," 1st Edition, McGraw-Hill.

A Shibley Award paper presented at the meeting of the Pacific Section of TAPPI held in Everett, Wash., March 15, 1960.

Operational Experience with Continuous Calcium Hypochlorite Systems

J. W. KLEIN and H. S. FISHER

A review and critical analysis of the bleach liquor manufacturing systems at the Longview Fibre Co. from batch through a manual continuous operation to the present automatic system. Flow diagrams for each phase are presented together with operating data. Bleach liquor quality in terms of uniformity, clarity, and chemical analysis together with chemical losses is discussed. Comparisons are drawn with similar bleach liquor systems operating in the area. A revised design for overcoming current operating problems and to provide increased capacity is included.

The Longview Fibre Co. at Longview, Wash., is a relatively old mill for the Pacific Northwest, having started operations in 1929. It has grown from the original coarse kraft paper board installation to a highly integrated paper and container operation. The original bleach plant was a small batch-type installation with calcium hypochlorite bleach liquor being prepared in a conventional batch system. As bleached pulp production increased, changes were made in the bleach plant, but the batch liquor system continued to supply requirements until 1954, when it became necessary to markedly increase calcium hypochlorite production.

FIRST SYSTEM

A completely automatic continuous system was discussed and it was felt that the art had progressed sufficiently to design a satisfactory installation. Two factors led to the decision to install a modified manually controlled system. First, the time available did not allow for obtaining all of the necessary instruments, control valves, etc. Second, the mill was still using screened lime for buffering the hypochlorite stage and the amount of excess lime carried in the bleach liquor for this purpose would move the e.m.f. control point into a very poor portion of the CaO–Cl_2 potential curve. Consequently, the installation shown in Fig. 1 was erected. This is a very simple system, and probably the first continuous bleach liquor installation in a Northwest pulp mill. Lime slurry strength was controlled by specific gravity measurement in what amounts to an enlarged section of pipeline.

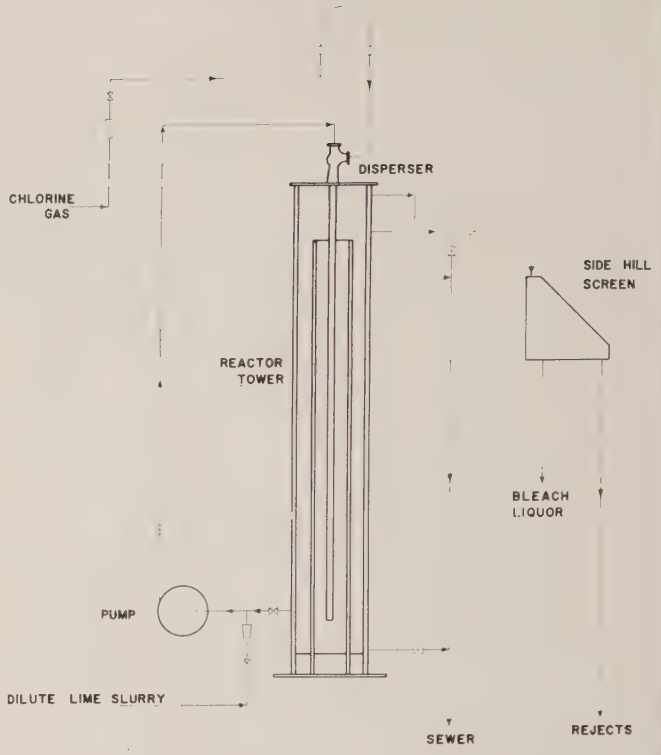


Fig. 1. Continuous hypochlorite system—1954

Calling upon past bleach liquor manufacturing experience, the incoming lime was mixed with a circulating stream of the hypochlorite and then the chlorine added through a disperser. This was to get the rapid, smooth chlorination reaction which is only experienced in the presence of hypochlorite ions. As this system discharged directly into the pulp mixer for the hypochlorite stage, it was only necessary to set the chlorine flow to the dosage required by the pulp and the lime flow to give the required excess for buffering. The system was designed for a production of 30 g.p.m. of 30 g.p.l. available chlorine bleach liquor. Actual production went as high as

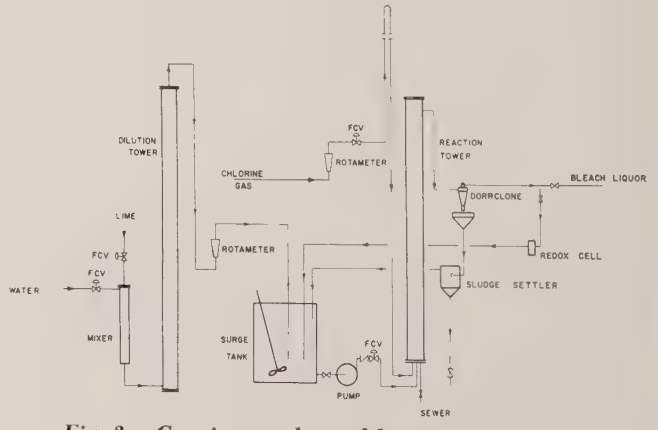


Fig. 2. Continuous hypochlorite system—1957

J. W. Klein, Director of Technical Services, Longview Fibre Co., Longview, Wash.; and H. S. Fisher, Technical Services, Pennsalt Chemicals Corp., Philadelphia, Pa.

60 g.p.m. of 60 g.p.l. bleach liquor without the odor of chlorine becoming apparent. The maximum production rate was never determined. Quality, or rather uniformity, was excellent—being a function of flow rates and lime strength. Chlorine gas was drawn from a controlled pressure and temperature heater. The pressure on the lime system was dependent only on the discharge from a centrifugal pump, and was constant at any given flow rate. Consequently, variations in flow rates through the control valves were not noticeable. The controller held the variation in the specific gravity of the dilute lime to within 0.001 g. per cc. or an overall variation in lime bleach liquor screen. Several materials were tried, but all quickly failed because of corrosion. The final solution was ordinary fly screen coated with a plastic type paint and used in several layers. This could be washed or acid-cleaned periodically.

The system performed satisfactorily and met the requirements of the mill. However, some problems were being experienced with color reversion and maximum brightness obtainable. Part of this was traceable to the use of lime as a buffering agent. The decision was made, therefore, to use caustic soda for buffering the hypochlorite stage and to produce as clean a bleach liquor as possible. Redox control of the bleach liquor end-point and better clarification could have been added to the existing system, but the equipment was in the way of the bleach plant expansion.

PRESENT SYSTEM

Results had been so good with so little labor and maintenance involved that management desired the rebuilt system to supply all bleach liquor requirements for the mill and to be operated by the regular bleach plant personnel. Consequently, the system shown in Fig. 2 was put in operation in May, 1957. This was designed for production rates up to 70 g.p.m. at an available chlorine concentration of 35 g.p.l. The existing lime-handling system was satisfactory with pebble lime being slaked in a continuous slaker and the milk of lime screened into storage through a 64 × 72 mesh sidehill screen. The dilution-control column is 8 in. in diameter with a pressure tap difference of 10 ft., balancing a column of water against a column of the diluted lime slurry. This gives a pressure difference of about 4-in. water column across the d/p cell controlling the lime flow. A minor change from the original design was made to correct inlet and outlet turbulence effects. Pressure fluctuations in the mill water-supply system made pressure control advisable. The diluted lime tank (100 gal.) was installed to reduce surges through the dilution system as a rapid flow-rate change in such a system has a temporary upsetting effect. Also, it provided a convenient place to put usable liquor from the centrifugal clarifier rejects back into the system. Chlorine gas is obtained from the regular bleach plant system being drawn from a controlled pressure and temperature header. Flow is controlled by redox potential measurement from a platinum-silver electrode pair.

The reactor installed was of the "draft tube" design first described by Pennsalt engineers in 1955, (*1*) embodying the circulation of hypochlorite into the incoming streams of chlorine and alkali as practiced in the original installation, but this time by natural internal means rather than by a pump. It is 10 in. in diameter by 10 ft. high, made entirely of unplasticized polyvinyl chloride. The centrifugal clarifier chosen was a 6-in. Model F. R. DorrClone. This is of cast iron, rubber lined construction. Trials have established that the use of a 2-in. vortex finder and $^5/_8$-in. apex nozzle with a pressure drop of 30 lb. across the DorrClone will give best operation of this particular system.

OPERATIONS

That soundness of the original design is borne out by the fact that since startup, the system has operated without major change or repair supplying the total bleach liquor requirements of the mill for over 3 years. Originally, the Redox electrodes were inserted in the reactor. Scale deposits on the sensing surfaces made it desirable to remove them to an external sampling cup where they are readily accessible for inspection and cleaning without shutdown. Reverse polarity cleaning of these electrodes did not prove satisfactory so they are now cleaned about once a day by an acid dip.

This raises the general question of scale problems. There is a slow scale buildup in the pipeline between the reactor and storage. It is cleaned about every 3 months. Although no scale buildup within the reactor has ever been apparent, it is given a precautionary acid rinse when cleaning the pipeline. The DorrClone does not function well at low rates of flow. Because of this and as the mill has ample bleach liquor storage, the practice is to operate the system at a more or less steady rate, shutting down when the storage becomes full and when the reserve reaches a low level. This is not bothersome as starting takes only about 5 min. of the bleach plant operator's time and shutdown less. Adjustable production rates could easily have been obtained by recirculating a portion of the product to maintain the DorrClone throughput in the desirable range.

The continuing problem is the automatic control of chlorination. The control of lime dilution is always automatic. If the lime and chlorine flows are manually set to give the desired degree of chlorination using the Redox potential as a measurement, the unit will operate and draw a practically straight line on the Redox chart. However, on automatic control when a slight variation occurs (usually caused by a drop in water pressure upsetting the lime control for a few seconds) the equipment is apt to start cycling and take some time to regain equilibrium. Cycling is caused by the control point being at the transition point where the potential curve changes from a low to a very steep slope. Therefore, degree of variation with unit change is much more pronounced above the control point than below it. Trials are scheduled to change the sampling point to see if a quicker response will help. Even though cycling does occur, the bleach liquor averages out to the desired test when mixed at the storage-tank inlet. Retention time within the system is so short that any acid hypochlorite produced under these conditions is made alkaline by this mixing before any decomposition occurs.

A part of the system which may be changed in the future is the equipment handling the DorrClone rejects. The coarse material settles rapidly leaving a usable solution to be recovered. This part works well, but after several hours compaction the settled material is very difficult to disperse and made to flow. Consequently, all rejects are wasted at present. As the current reject rate is 0.7 g.p.m. for a flow of 58 g.p.m. of bleach liquor, the chemical losses from the system approximate 1.25%. Losses from the batch system were 2.2% for both chlorine and lime. Overall losses during periods when an effort was made to keep the grit separation system operating were 0.33%.

Operations have been very consistent and acceptable with the normal variation of chlorine concentration being in the order of 0.2 g.p.l. when operating in the 40 to 50 g.p.l. available chlorine range. Excess CaO is held at the level 0.5 ± 0.1 g.p.l., which is well below the solubility limit. It is quite normal for the bleach-plant operator to occasionally change

Table I. Lime Slurries

	Mill			
	A	*B*	*C*	*D*
Partical size:				
Solids through 200-mesh screen, %	99.90	100.00	100.00	99.98
Final settled volume:				
Slurry volume after 16 hr. settling, %	45.0	23.5	11.1	23.7

Table II. Bleach Liquor Analysis

	Mill A	Mill B	Mill C	Mill D
Available chlorine, g.p.l.	45.5	55.5	33.1	35.6
Excess CaO, g.p.l.	0.3	0.5	0.1	0.2
Solids, g.p.l.	7.57	8.46	6.45	1.58
Solids analysis:				
CaO as $Ca(OH)_2$, %	2.77	2.34	...	0.62
MgO as $Mg(OH)_2$, %	11.4	6.51	23.8	21.0
$CaCO_3$, SiO_2, etc., %	85.8	91.1	76.2	79.3
Screen analysis of solids:				
Retained on 200-mesh screen, %	0.0	0.0	0.02	0.0
Settling rate, % clear volume:				
5 min.	87.8	...	82.2	75.8
15 min.	88.7	68.5	87.3	82.8
30 min.	89.3	74.7	89.3	86.4
60 min.	89.5	78.7	91.3	89.0
Final	91.3	88.4	91.8	90.0

the strength of the liquor to meet particular demands. The upper strength limit is determined by final temperature with 110°F. being considered an acceptable maximum under mill conditions. When it is necessary to exceed this because of production demands, an effort is made to avoid prolonged storage. As stated earlier, no calcium hypochlorite presently being produced using centrifugal clarifiers for removal of objectionable solid material is clear or entirely transparent. It has been stated (*2, 3*) that the solids left in the bleach liquor, being very fine and flocculent, do not cause difficulties in bleaching.

COMPARISON OF RESULTS

In order to compare operations, samples were obtained from the other three pulp mills in the northwestern states producing calcium hypochlorite by a continuous process. Except for size, process flows sheets and equipment at these mills are almost identical with that shown in Fig. 2 except that mill D (Table I) performs extensive cleanup operations on the lime slurry and does not attempt clarification of the final bleach liquor. Mill A is the Longview Fibre Co.

Table I indicates that all of the mills are performing satisfactory lime-slurry cleaning. There is a large difference in settled slurry volume which can only partially be explained by difference in concentration. All mills are using fresh lime of about equal quality so that the difference is a physical characteristic due to source, etc.

The bleach liquor comparisons are made in Table II. All samples show good chlorination control with the excess CaO content carried in the range of solubility. The liquid analyses were made on agitated rather than settled samples so that the effect of solids would be shown. The screen analyses indicate acceptable cleaning being performed.

Analysis of DorrClone rejects, Table III, indicates that there is a negligible amount of usable material other than the liquid being discharged, as it is known that only calcium hydroxide and not magnesium hydroxide or calcium carbonate

Table III. DorrClone Reject Analysis

	Mill A	Mill B	Mill C
Reject rate, % total flow	1.25	25	18
Solids, g.p.l.	120.3	6.45	24.3
Solids analysis:			
CaO as $Ca(OH)_2$, %	7.04	3.88	1.32
MgO as $Mg(OH)_2$, %	2.52	6.26	12.15
$CaCO_3$, SiO_2, etc. %	90.4	88.8	86.5
Screen analysis of solids:			
Retained on 200-mesh screen, %	0.60	0.08	0.03
Settling rate, % sludge:			
5 min.	81.3	...	19.2
15 min.	44.8	34.9	13.7
30 min.	29.2	23.6	11.1
60 min.	27.1	20.5	11.1
Final	26.1	11.3	11.1

Table IV. Settling Rates of Bleach Liquor
Volume of Sludge (Per Cent) After Indicated Settling Time

	Continuous systems A	B	C	D	Batch systems X[a]	Y[b]	Z[c]
5 min.	12	..	18	24	78	74	22
15 min	11	31	13	17	47	36	15
30 min.	11	25	11	14	36	25	12
60 min.	10	21	9	11	31	19	10
16 hr.	9	12	8	10	19	11	6

[a] X = average of 3 high mills.
[b] Y = average of 3 middle mills.
[c] Z = average of 3 low mills.

will chlorinate at the normal bleach-liquor pH. In the case of the Longview Fibre Co. the amount of available lime in these rejects amounts to less than 55 lb. per day at maximum production. Separation of the product liquid from the solids is simple because of the rapid settling rates. The solids, having no value, should be immediately discharged from the system so as to reduce abrasion.

Data, incomplete for inclusion in the tables, were received from another kraft mill using reburned or recovered lime in a continuous automatic system. In this case the diluted lime analysis was equivalent to 84.5% available calcium hydroxide on a dry basis. As might be expected the amount of sludge was high, but the solid material from the DorrClone rejects analyzed only 0.56% available CaO making any attempt at recovery useless.

It has been known to the authors for some time that calcium hypochlorite made in the Longview Fibre Co. system settled very rapidly, presumably because chlorination can safely by carried to the point where all calcium hydroxide is in solution. This not only reduced the amount of sludge over that usually found in a batch bleach-liquor system, but also completely eliminates slow settling, finely divided, lime particles. In Table IV settling rates for the bleach liquors reported previously are compared to bleach liquors made by the conventional batch process. To simplify comparison, results from the ten batch systems were grouped in classes as shown. It is seen that the automatic continuous systems produce bleach liquor with superior settling qualities.

These settling data are presented for two purposes. First, for those mills that wish to consider completely automatic continuous manufacture of calcium hypochlorite, but do not wish to operate with the normal amount of fine flocculent material in the bleach liquor, it will give data for the preliminary design of clarification equipment. It must be pointed out, however, that amount of sludge settling rates, etc., are also a function of lime source so that this must be considered in the final design. Second, those mills with batch bleach-liquor systems having difficulty with settling capacity may wish to consider the advantages to be gained through use of Redox potential control of the end point of chlorination.

SUMMARY

The present continuous calcium hypochlorite system at the Longview Fibre Co. has functioned for over 3 years without change or major repair, supplying the entire bleach liquor requirements of the mill for this period without interruption. Chemical, operating labor, and maintenance costs are less than for the previous batch system. Quality of bleach liquor has been found to be equal to other mills. Information has been developed which can be used for improvement of quality and efficiency.

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Water Treatment at Abitibi Mills

G. L. STUART

A short description is given on the water treatment systems of several Abitibi mills.

THE Abitibi Power & Paper Co. Ltd. and its wholly owned subsidiary companies operate 11 mills in eastern Canada and a new mill in Michigan. Six mills produce newsprint, the others produce fine papers, various boards, bleached sulfite, and coated papers. During the past 10 years, 15 new boilers were installed and two boilers rebuilt in the Canadian mills under Abitibi's expansion and modernization program. In three of the mills having large electric-boiler installations, the new boilers eliminated any dependence on the availability of surplus hydroelectric power for steam generation.

The new boilers, ranging in capacity from 60,000 to 165,000 lb. per hr. steam all had very much higher furnace heat liberation rates than had the old boilers. This brought the matter of water treatment and the control of boiler water constituents very much to the fore as all the mills, with the exception of two, had run for many years with only internal chemical treatment. The problems, however, were appreciably mitigated by the steam pressures being in the low range of 150 to 345 p.s.i.

Several types of waters are encountered. Three mills enjoy the clear, colorless water of Lake Superior; most must contend with bush-type waters usually high in organic color and, in one case, high in turbidity and silica concentration. Another uses water from a busy canal, while the small coating mill must put up with hard well water. With the exception of the latter two, the waters are soft to moderately soft with the hardness ranging from 15 to 60 p.p.m.

Pollution by municipal sewerage or industrial waste is, fortunately, no problem in the northern mills as the rivers drain largely undeveloped areas. In the three mills located in industrial areas and using Lake Superior water, suspended matter can be troublesome at times, especially during storms.

As far as process water is concerned, the removal of gross suspended matter by screening is all that is necessary except in the fine paper mill served by the canal. During spring runoffs and those previously mentioned storms, several of the screening systems are seriously taxed by the increased amounts of organic matter and, in one case, the presence of considerable fine sand. Let us look at the water, the operating conditions and the treatment facilities where treatment other than sodium zeolite softening has had to be provided.

MANITOBA PAPER CO. LTD., PINE FALLS, MANITOBA

Located about 80 miles N.E. of Winnipeg, the source of water for this 475 ton newsprint mill is the Winnipeg River. River flows range from 18,000 to 32,000 cu. ft. per sec. The watershed is very largely bush country. The water has moderate color and is relatively soft, the hardness averaging 45 p.p.m. Turbidity runs from 7 to 12, and silica from 1 to 2 p.p.m.

Process water is taken directly from the mill pond. Two Andale strainers and a Kinney self-cleaning strainer serve to remove gross suspended solids. No further treatment is required.

Potable water for the town is taken through an intake located well upstream from the mill pond. Conventional filtration, employing alum coagulation, settling and gravity sand filters, gives an excellent water, low in color and turbidity. Alum dosage runs from 15 to 25 p.p.m.

Makeup for the fuel and electric boilers operating at 200 p.s.i. is treated by hydrogen zeolites, degasified and neutralized by caustic. Because of the low sulfates and chlorides in the raw water and the liberally sized decarbonator, the system removes most of the dissolved solids. The plant was placed in service late in 1958 along with a 165,000 lb. per hr. steam boiler. Sodium zeolite softening would have met the requirements of this boiler but it was the opinion that the high solubility of the sodium salts would have upset electric boiler operation. These boilers can carry up to 75% of the demand. A separate intake upstream of the mill was provided as the mill intake occasionally showed traces of oily wastes and appreciable organics from the nearby wood pond. The exchanger units are equipped with rotary washers to remove impurities retained by the beds. The exchanger is carbonaceous zeolite. The steam demand averages 165,000 lb. per hr.; makeup 40%.

PROVINCIAL PAPER LTD., PORT ARTHUR, ONTARIO

The source of water for this fine paper and bleached sulfite mill is Thunder Bay on Lake Superior. The water is very low in color and turbidity, has an average hardness of 45 p.p.m. and contains little or no silica, sulfates, and chlorides. Suspended matter varies considerably.

Process water is taken through a 2200 ft. offshore intake. Suspended matter is satisfactorily removed by North self-cleaning rotary filters. Other than chlorination the water receives no further treatment.

Makeup for the fuel and electric boilers operating at 150 p.s.i. is taken off the process system and conditioned by a hydrogen zeolite + degasifier + caustic neutralization plant similar to the Pine Falls installation. The system was installed early in 1953, primarily to reduce carryover in the boiler steam, boiler sludges, and corrosion of condensate piping. As the electric boilers can carry upwards of 80% of the mill demand and as there was insufficient condensate returns to meet this load, makeup low in dissolved solids was required. This was easily achieved treating Lake Superior water with hydrogen zeolites.

The steam demand averages 115,000 lb. per hr. steam; makeup about 50%. Treatment chemical cost is around 2.8 per M U. S. gal. The styrene resin shows no falling off in exchange capacity after nearly 7 years service, and only 20 cu. ft. has been added to make up for losses. Mid-cycle backwashing is practised to free the beds and remove the impurities collected. Finely divided matter and fibrous slimes of little concern to the paper mill, are retained by the ex-

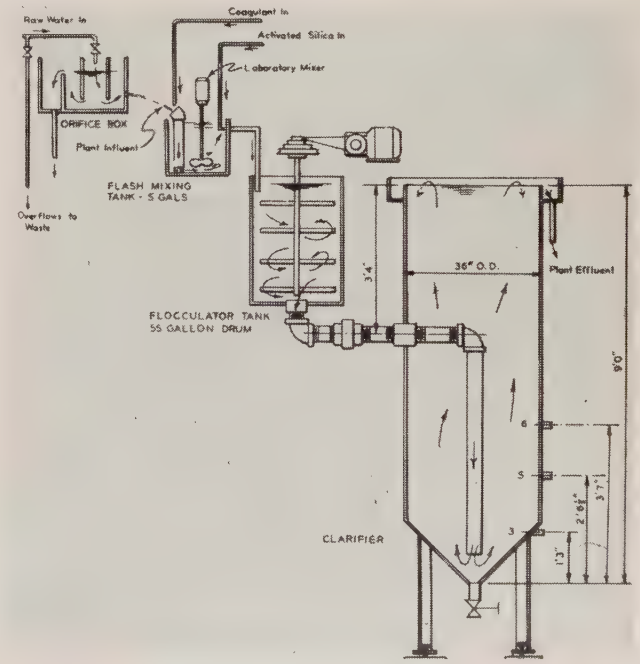

Fig. 1 Pilot plant, upflow solids contact clarifier

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changer beds. Subsurface washers are now being installed to speed up removal of this matter.

THUNDER BAY DIVISION, PORT ARTHUR, ONTARIO

Being less than a mile from the Provincial mill, the source of water for this 430-ton newsprint mill is also Thunder Bay.

Process water is taken from the shore end of the boat slip. A traveling trash screen, stationary vertical screens and North self-cleaning rotary filters remove the suspended solids. Except for the addition of chemicals to control slime, no further treatment is done.

Makeup for the boilers operating at 345 p.s.i. is screened and chlorinated water from the city pumping station served by a 2400 ft. off-shore intake. The water is softened and de-alkalized by a sodium zeolite-chloride anion system. This system does not remove any of the dissolved solids, simply converting everything except iron and silica to sodium chloride. The plant was installed late in 1953 to replace two overloaded, upflow, greensand zeolites and to reduce condensate system corrosion and the return of iron and copper to the boilers. These appeared to be the main reasons for the epidemics of bulged furnace tubes in a new stoker-fired boiler extending over a two-year period.

The low capital investment, small space requirements, the freedom from acid handling, and the elimination of pumping and instrumentation led to the choice of this system. The small, rarely operated, 5000-kw. electric boiler had no bearing on the problem as it could easily be fed with condensate or raw water. City water is used because of the strong possibility that oil, organics from bark, and drainage from the coal piles could contaminate process water. Rotary washers are installed in the sodium zeolite units.

Steam demand averages 150,000 lb. per hr.; makeup 25%. Treatment chemical cost is around 5.8 per M U.S. gal. The anion units show no falloff in exchange capacity after 6 years' service. Actually, the volume capacity is slightly up. Thus, no longer is concern felt about the possibility of organic fouling of the resin. Six cubic feet of anion resin have been added in the 6 years to makeup for losses.

PROVINCIAL PAPER LTD., THOROLD, ONTARIO

The source of water for this 160-ton fine paper mill is the Welland Canal. Turbidity varies from 20 to 100 p.p.m. Dredging can muddy the water.

Process water is clarified by alum coagulation, settling, and filtration. The filtration plant was supplied by Hardinge. Sludges are removed continuously and the filters are automatically backwashed. The two filters contain a compartmented filter bed with an 11-in. deep sand bed supported on porous media.

The turbidity of the filtered water runs 2 to 3 p.p.m.; the alum dosage average 10 p.p.m. Chlorine is also added for control of bacterial and slime growth.

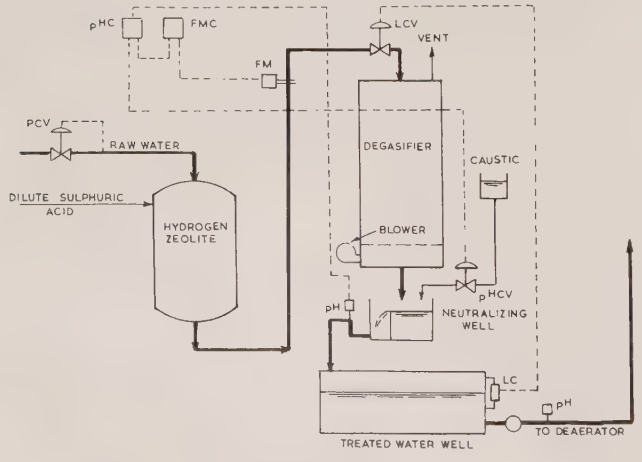

Fig. 2 Hydrogen zeolite + degasifier + caustic + neutralization

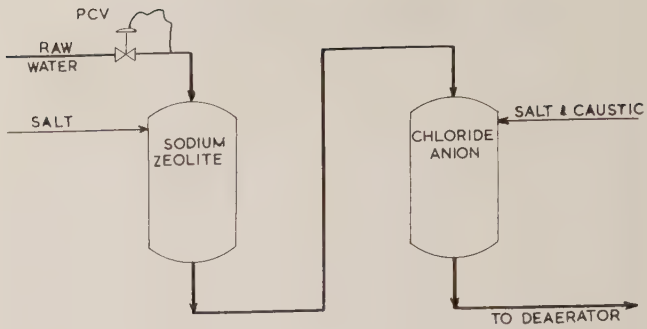

Fig. 3 Sodium zeolite + chloride anion exchanger

The plant was started up early in 1954. Maintenance on the sludge-removal mechanisms and the backwash carriages has been very small. The filter beds are sterilized about every two years.

Makeup for the boilers operating at 250 p.s.i. is taken off the process system. The water is fairly hard, averaging around 135 p.p.m. M. alkalinity is around 90 p.p.m. The water is softened and partially de-alkalized by hydrogen and sodium zeolites operating in parallel followed by a degasifier.

The steam demand averages around 75,000 lb. per hr. makeup is low at 15 to 20%; as all pulp is purchased.

IROQUOIS FALLS DIVISION, IROQUOIS FALLS, ONTARIO

The source of water for this 850-ton newsprint mill located in northern Ontario is the Abitibi River. The water is highly colored, and the total silica is also high, varying from 9 to 48 p.p.m. Hardness averages 58 p.p.m. "Difficult" is the term applied to this water.

Process water is taken from the hydroelectric plant forebay. Side-hill screens covered by fourdrinier wire serve to remove trash and gross suspended matter. Other than chlorination, the water received no further treatment.

Potable water is treated in a conventional plant using alum coagulation, settling, and gravity sand filters. The filtered water quality is poor, particularly during cold weather. Color, residual alum, and colloidal silica are present. Apparently owing to the presence of organics, only a small, light floc is formed, which taxes the inadequate facilities of the plant. The alum dosage runs between 100 and 125 p.p.m.

Makeup for the boilers operating at 225 p.s.i. is filtered by Davis pressure leaf filters precoated with a mixture of diatomaceous earth and asbestos and employing a small body feed of diatomite. The filters were installed in 1950 as an emergency measure following a trial of pressure filters employing a line mixer and a roughing filter. The Davis units remove 70% of the turbidity and reduce the color by 35%. Fuel boiler makeup is sodium zeolite softened. The electric boilers are fed condensate. The dual preboiler system was installed many years ago owing to the heavy bleed required by the electrics when the feedwater contained even small amounts of raw water.

Steam demand averages 265,000 lb. per hr. The makeup averages 22%. With the electric boilers in service, the percentage of makeup in the fuel boiler feedwater will go as high as 50%.

Before the paper machine engines were replaced, and for a considerable time afterwards, the condensate was heavily contaminated with oil. Davis pressure leaf filters precoated with diatomaceous earth consistently reduced the oil content to less than 1 p.p.m. The filters presently serve to trap the corrosion products resulting from carbon dioxide attack on the now oil-free surfaces. Corrosion is especially rapid in the drier drops where the velocity of the steam-condensate mixture is high.

The Davis raw-water filters certainly saved the day; but they are not the long-term solution to the filtration problem. The occurrence of some five tube bulges over the past few years and the study of scale analyses indicate that a further reduction of silica and natural organics is desirable. The occasional breakthrough of filter media and material filtered from the water has resulted in excessively high silica concentrations. The cost of diatomite and asbestos is around 104 per M U.S. gal.

Sheppard T. Powell and Associates were retained 3 years ago to find an answer to the clarification problem. After running numerous jar tests employing various coagulants and coagulant aids, Dr. Goodson set up a pilot plant to try the most promising combinations. The plant consisted of a small reactor, pressure filter, and sodium zeolite softener with the essential automatic controls. Trials were conducted on hot process softening and after modifications to the reactor, on cold water clarification.

Upflow solids contact clarification employing alum and activated silica gave much the best results. It was possible to reduce the turbidity to 2 p.p.m. and color to 10 units with a rise rate in the reactor of 0.6 U. S. gal. per min. per sq. ft. The average chemical dosage was 75 p.p.m. alum and 8 p.p.m. activated silica. The trials were run with an influent temperature of 35°F. The total silica was reduced to 5 p.p.m. This should permit carrying favorable boiler silica concentrations with only a moderate blowdown.

Another advantage that cold water clarification possesses is the reduction of alkalinity from 45 to 12 p.p.m. Softening by the existing sodium zeolites would be all the treatment necessary, and only a small feed of a volatile amine would be required to minimize condensate system corrosion.

The case of the difficult water appears to be closed. The question now is: Should the boiler makeup and potable water treating plants be combined? In the meantime, the Davis filters are keeping the boilers on the line.

STE. ANNE PAPER CO. LTD., BEAUPRÉ, QUEBEC

The source of water for this 430-ton newsprint mill is the Ste. Anne River. It is a soft water having an average hardness of 15 p.p.m. This is the other extreme of what?

Process water is filtered by self-cleaning rotary filters covered with nylon cloth. Very fine sand is troublesome during the spring runoff for a few days.

Makeup for the fuel and electric boilers operating at 225 p.s.i. is untreated. The feeding of a phosphate—organic treatment to the feedwater main has served to keep the fuel boilers in excellent internal condition.

GENERAL

In the other five mills located in Ontario, there is little of interest to report except in the Smooth Rock Falls division. Here, 16 horizontal pressure filters have long been employed to remove suspended solids from the highly colored but normally low turbidity Mattagami River water. Sodium zeolite softening or a 100% internal chemical treatment has so far sufficed to keep the boilers and the preboiler systems in good condition in these mills.

In the Abitibi Corporation mill located at Alpena, Mich., a hot lime–hot zeolite system is employed to condition makeup for the 850-p.s.i. boilers. About 18 months ago, the source of makeup was changed from the intermittently polluted and variable Thunder River to the city system taking water from Thunder Bay on Lake Huron. Reactor performance was much improved and there have been no further reports of troubles. Rapidly cycling makeup flows will soon be reduced by the installation of an accumulator to smooth-out the press and digester on-off steam loads.

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The FRAG Tester—A Design Tool for the Sack Maker?

SANGHO BACK

Both the FRAG and progressive drop test inflict the same type damage on the multiwall sack through similar stress patterns and the correlation between the two tests was excellent in their cubic functions for different papers used in the same sack construction. No direct correlation exists between the two tests on different sack constructions. However, the relationships were of the same form; differing only by a functional constant which changes with changes in construction features. The drop test was influenced by changes in number of plies and basis weight in the same way as the FRAG results. However, the FRAG was found to be more useful for it can compare the resistance to impact stresses for different qualities, numbers, and weight of plies in a more reliable, simpler, and less costly fashion than does the drop test.

A LARGE amount of work has been done to develop a reasonable test method for both parent papers and multiwall sacks which will predict end-use performance. However, definite criteria have not been available for judging whether a given sack paper or sack is suitable for practical use.

The mechanical stresses a sack must resist in use begin as it is being filled, and the fact that these stresses occur under widely varying conditions makes their duplication in the laboratory difficult. The classical test methods, such as tensile, tear, fold, and burst, tell little about the suitability of a paper for sack making, and, judging by the specifications now in use for sack papers, a great deal of unsuitable paper is being accepted while perfectly adequate paper is probably being rejected. This seems apparent, since the classical tests employ static forces to the paper while, in practice, dynamically acting forces are primarily responsible for most sack failures attributable to unsuitable paper.

A wide variety of impact tests is used in the laboratory to test the suitability of sacks. Those commonly used are drop test, tumbling drums, shoulder throws, and inclined planes. All such tests have advantages and disadvantages in use. As a group these tests have certain controllable elements such as impact forces, sack position, and conditions of temperature and humidity. However, they have a large inherent variation since the whole package is being tested. Variations have been encountered ranging from 12 to over 50% of the mean value, so a large number of tests are usually necessary to obtain a reasonably accurate picture of the sack's suitability. The greatest problem, however, is the lack of uniformity in testing equipment.

Data from a large number of routine control tests and special experiments give a good basis for comparing the tests in terms of usefulness (*1*, *2*, *3*). Comparing the reproducibility of these tests, the drop test appears best. The drop test of multiwall sacks gives good correlation with field performance (*4*, *5*, *6*). The drop test can, therefore, be used by the sack maker to determine the suitability of his product with reasonable accuracy, but so far the papermaker has no way of judging his paper's potential suitability for use until someone complains.

FRAG TESTER

A relatively new dynamic instrument called FRAG has been made available to the papermaker recently. The FRAG tester is an instrument designed to determine the practical resistance of paper to dynamic stress. The instrument is claimed to duplicate the stresses to which a sack paper is subjected in practice, and it can be used to test several plies at once (*7*). If this is true, the result could give the

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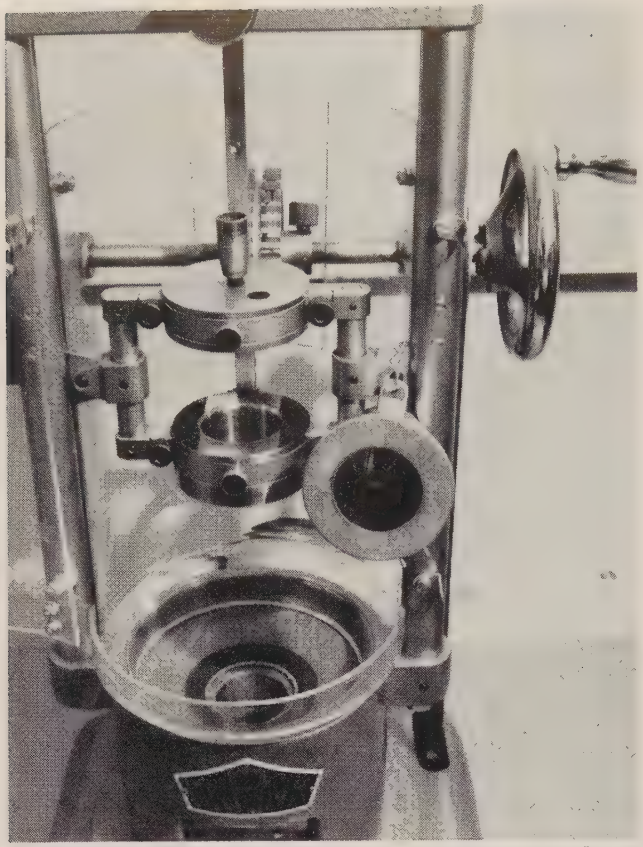

Fig. 1. FRAG tester showing the paper holding device

sack maker information about his sacks which previously could be gained only through extensive drop testing or field trials. The purpose of the investigation described in this paper was to determine the usefulness of the FRAG tester for judging the potential suitability of paper and for sack design.

The FRAG instrument used in this evaluation is shown in Fig. 1. It was purchased from a German manufacturer for $971. The conical cup shown in the center of the picture is placed on top of a $2^1/_2$-in. square paper specimen, then is filled with the desired weight of 1 mm. shot. A set screw forces the can tightly against the paper. The can and the straps attached to the rack gear are lifted by a pinion and dropped continuously until a break occurs in the specimen. The instrument is designed so the amount of shot may be varied to a maximum of 250 g. using either the 14 or 21 cm. dropping height. In this way, a drop energy level can be selected for any material to give a drop number in the 5- to 50-drop range.

Some problems were encountered in using the tester which necessitated some changes in the instrument. These consisted of providing double clamping on the sample-holding edges instead of the single screw clamp in the middle of the can, providing a constant and known clamping pressure with a torque wrench, and devising a template to properly align the directions of the paper specimen.

The test is reported in terms of the absolute bursting energy which is calculated from the drop number by equation (1)

$$\text{Absolute bursting energy} = \sqrt[3]{B}\, X_s \qquad (1)$$

where:

B = drop number
X_s = stress level (weight of shot × height of drop)

The absolute bursting energy is defined as the force considered necessary to break the specimen at the first drop, and is an indication of its resistance to dynamic stress. This is what the instrument should tell about a given sack paper, and the experimental work was designed to see if the results had practical application for the paper and sack maker. To do this, the FRAG was compared with the progressive type drop test by assuming that both tests inflict the same type stress damage on the sack paper or sack and that the test results will differ by some proportionate factor. With this assumption, it was possible to deduce the type of relationship by considering the stress conditions imposed on the test specimen by the two methods. The drop test would be directly proportional to the FRAG in their cubic relationship as shown in equation (2)

$$S^3 = K'(E)^3 + C' \qquad (2)$$

where:

S = safe-inches of drop

$$K' = \frac{10.648}{x_s^3}\,(x_s - a)^2$$

$$C' = K'\,\frac{(2a - d)}{2d}$$

The derivation of the above relationship is shown in the Appendix.

EXPERIMENTAL WORK

Experimental work was designed to include drop testing of paper of several qualities which had been converted into two different sack constructions and sizes. Sacks were 8 by 3 by 31 SV of 3/40 and 4/40 construction, and $18^1/_2$ by $23^3/_8$—$3^1/_4$ PV stepped-end cement sacks of 4/50 construction. To see what effect differences in the CD stretch between plies in the same sack might have, two sets of sacks were made combining two high stretch edge papers as inner plies with two low stretch center papers as outer plies. A total of about 350 sacks was tested in an elevator type progressive drop tester, using about 25 bags per set so that the differences between sets would be significant at a probability level of being right 95 out of 100 times. Sacks were rotated from face to back at each of the successively higher drops. The filling material was sand and 64 and 92 lb. were used for the respective size sacks.

The results of the drop tests, their mean values ($\bar{X}$), and the derived relative dispersion (% RD) of the individual measurements about the mean values are given in Tables I and II. About 100 of these drop tests were discarded due to testing errors, converting defects, or packer damage so that any difference between sets was primarily due to differences in paper quality.

Parent papers were tested on the FRAG in the cross-machine direction only since a closer relationship seemed to exist with respect to the drop test than when using with-machine results. With-machine direction properties of normal kraft papers are similar at a given weight paper, so their effects could be grouped into a constant. The FRAG specimens tested for correlation with the drop test were taken from the face of the unstrained sack and ten individual

Table I. FRAG and Drop Test for 3/40 and 4/40 SV Sacks[a] Made from Experimental Kraft Papers

Sack construction and type paper	*FRAG B.E.,[b] in.-lb.*	*Drop test, safe-inches*	*No. of bags tested*
3/40 Kraft (A), $\bar{X}$	4.32	114.7	25
% RD [c]	7.9	58.5	
3/40 Kraft (B), $\bar{X}$	6.26	242.3	25
% RD	15.2	48.7	
3/40 Kraft (C), $\bar{X}$	7.81	418.6	25
% RD	9.8	58.1	
4/40 Kraft (B), $\bar{X}$	10.18	562.0	24
% RD	18.3	33.4	
4/40 Kraft (C), $\bar{X}$	11.63	613.4	25
% RD	15.6	49.1	

[a] Sack size was 8 × 3 × 31; load was 64 lb. sand.
[b] FRAG cross-machine absolute burst energy.
[c] % RD is the dispersion of the individual measurements about the mean values.

Table II. FRAG and Drop Test for 4/50 Stepped-End Cement Sacks[a]

Construction & type paper	Av. CD stretch, %	FRAG B.E.[b] in.-lb.	Drop test at failure, safe-in. Plies 4-3	Drop test at failure, safe-in. All plies
4/50 Low Stretch Center Paper (A), $\bar{X}$	2.3	13.29	192.4	192.4
% RD[c]	..	17.8	37.4	37.4
4/50 Low Stretch Edge Paper (B), $\bar{X}$	3.4	18.01	357.6	357.6
% RD	..	17.9	18.5	18.5
4/50 Hi-Stretch Center Paper (C), $\bar{X}$	4.1	20.96	418.5	418.5
% RD	..	19.5	19.8	19.8
4/50 Hi-Stretch Edge Paper (D), $\bar{X}$	5.5	27.65	472.8	472.8
% RD	..	17.5	19.4	19.4
2/50 (D) Edge & 2/50 (A) Center $\bar{X}$	..	13.10	175.1	252.0
% RD	..	15.3	36.4	18.9
2/50 (D) Edge & 2/50 (C) Center $\bar{X}$	..	15.37	324.5	405.4
% RD	..	33.1	17.4	17.7

[a] Sack size was $18^1/_2 \times 23^3/_8$—$3^1/_4$; load was 92 lb. sand.
[b] FRAG cross-machine absolute burst energy.
[c] % RD is the dispersion of the individual measurements about the mean values.

tests were made in each set. Special experimental papers were made by adding internal bonding materials of three different kinds of six different levels to provide a variety of paper qualities for the study of ply effect.

DROP TEST VERSUS FRAG

The results of the drop tests and FRAG tests are plotted in Figs. 2 and 3. Figure 2 shows the correlation of the 3/40 and 4/40 SV sack drop test to the parent papers' burst energy, and Fig. 3 shows the correlation of the 4/50 PV cement sacks drop test to the parent papers' burst energy. The correlations are shown in their cubic functions. There is apparently a good correlation within each individual series, but the values of different series of the different sack constructions are not comparable upon first inspection. A statistical check of the relationships between the measured values of each individual series gave correlation coefficients of +0.99 for the experimental paper group and +0.94 for the commercial paper group. The test of significance for such correlations was reached at 99%+ for both groups when examined by their F ratios. Therefore, within the range of the experimental work, the validity of the derived equation (2) may now be considered as confirmed. The

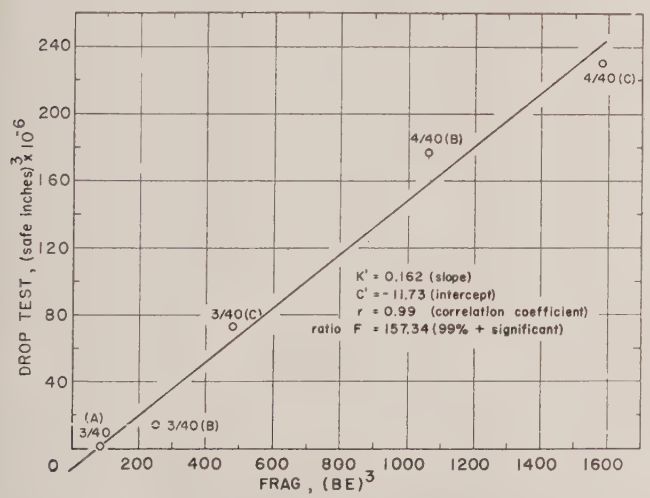

Fig. 2. Cubic relation of FRAG and drop test of 3/40 and 4/40 SV sacks made from experimental papers

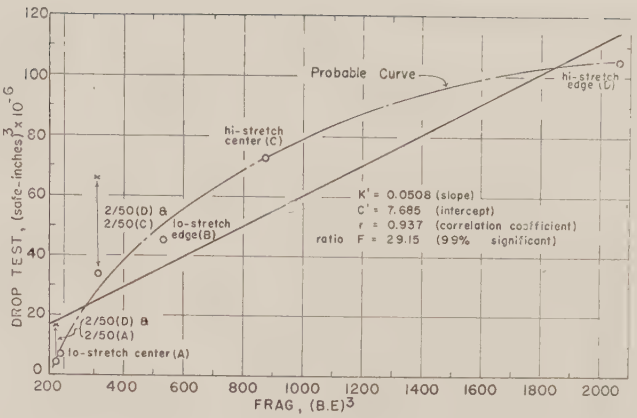

Fig. 3. Cubic relation of FRAG and drop test of 4/50 PV stepped-end cement sacks made from commercial papers

constants were determined empirically. The slope K' was determined as 0.162 for the experimental paper group (I) and was 0.0508 for the commercial paper group (II). The intercepts C' were −11.735 for the group (I) and 7.685 for the group (II). In the K' constant, the a term (which is the limit of elasticity) is small and negligible when compared to x_s, so K' would be predominantly influenced by x_s. But since x_s represents the magnitude of stresses inflicted in the sack paper, it would be mainly governed by the construction features such as the geometry of the sack and the filling material. Therefore, K' is related to the construction features.

The terms in the C' constant are K' and d (the progression of height and the magnitude of stress). The progression of height is equivalent to 6 and the magnitude would be comparable to the value of the elastic limit a, so the term $(2a - d)/2d$ would approach zero. Therefore, the constant C' would be insignificant although it could be somewhat influenced by the material tested and the construction features of the sack. This is demonstrated in Figs. 2 and 3 where the intercepts do not deviate too much from the origin. In the case of the experimental paper group (I), the C' intercept is negative, which could mean that the progression of height was greater than the limit of elasticity.

Effect of Ply Qualities

Looking at Fig. 3, one readily sees an inconsistency occurring in the way the sets made from both edge and center paper are ranked by the two test methods. In the sacks containing two qualities of paper, the weaker outer plies failed two to three drops before the stronger inner plies. They gave sack performance levels less than the average potential of the paper being used. In the FRAG test, this effect was

Table III. Ply Interaction Factor—Effect of Type Treatment and Treatment Level of Paper

Type treatment	Treatment level 1	2	3	4	5	6	Level av.
(A)	1.505	1.459	1.503	1.459	1.472	1.487	1.481
(B)	1.618	1.594	1.532	1.551	1.542	1.622	1.577
(C)	1.500	1.478	1.548	1.448	1.495	1.433	1.484
Type av.	1.541	1.511	1.528	1.486	1.503	1.514	1.514

Analysis of variance

Source	Calculated F Ratio	F Ratio at 95% C.L.
Type treatment	2.129	4.10
Level treatment	5.477	3.33

Duncan's Multiple Range Test Between Levels for 5% Significance

Standard error of a varietal mean 0.01612
Varietal means ranked in order

No. 4	No. 5	No. 2	No. 6	No. 3	No. 1
1.486	1.503	1.511	1.514	1.528	1.541

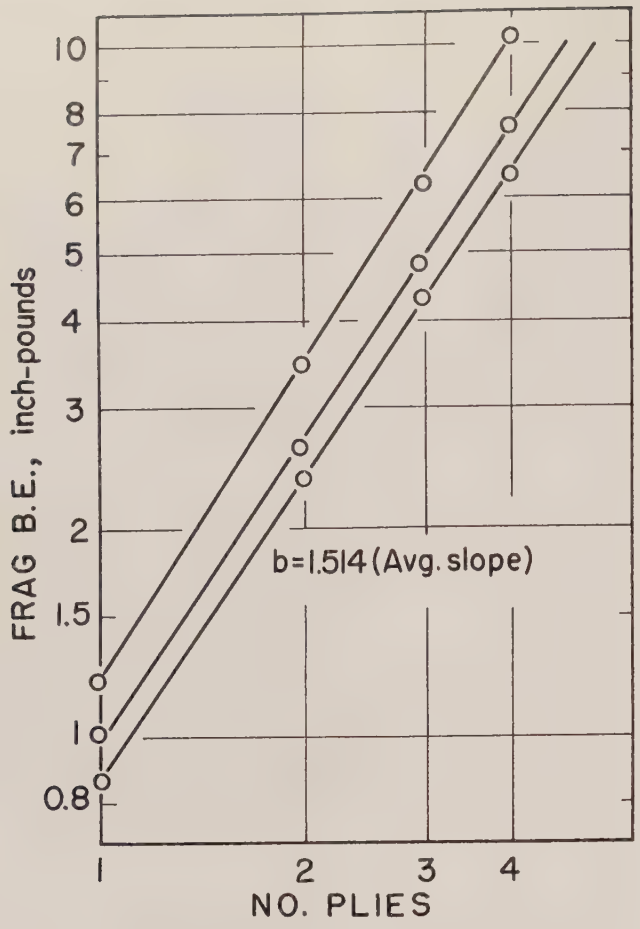

Fig. 4. Relationship between number of plies and FRAG B.E. for experimental papers

more pronounced with the failure occurring at a level less than the weaker paper. This difference between the drop test and the FRAG in ranking two plies of different paper quality may be due to the change in the stress distribution or in the construction features. Inspection of these sacks showed the outer plies were tighter than the inner plies of high stretch papers which were loose and sort of washboardy. In the other sacks, and in the FRAG test specimens, this "nesting" effect was not found. Therefore, a construction feature could have been changed, and we might expect this to contribute to the noted discrepancy. Similarly the functional constant K' in Fig. 3 could have changed on all sets of sacks tested possibly due to the changes in "nesting" effect brought about by the increased CD stretch in the paper so the probable regression is curvilinear. This may explain why the linear relation was not as good as the experimental paper group.

Ply Interactions

The results described so far have demonstrated how the FRAG and progressive drop tests inflict similar stress damage on the test specimen, and that they are both influenced similarly by changes in paper properties. Therefore, it seems likely the drop test would be influenced by changes in number of plies and basis weight in the same way as the FRAG results. If true, some clues as to how these construction features affect drop test performance may be obtained from the FRAG test.

It was found that the FRAG bursting energy is increased at an accelerated rate as the number of plies used is increased. This is shown in Fig. 4 on logarithmic coordinates. The relationship between FRAG bursting energy and number of plies can be represented by a power equation of the general form:

$$Y = aN^b \qquad (3)$$

where:

Y = bursting energy
N = number of plies
a = proportionality constant describing paper quality
b = power function defining the ply interaction factor

It was also found that the ply interaction factor was essentially the same for 1, 2, 3, 4-ply construction of 40-lb. kraft treated with three different types of internal bonding material at six different levels. Table III gives such ply interaction data. The ply interaction factor averaged 1.514 with a standard deviation of 0.0161 or a relative dispersion for any individual test of less than 2% about the mean. The analysis of variance indicated that, at 95% confidence limit, the ply interaction factor was not changed by the different types of treatment though it changed with the level of treatment. Further comparison of the data between the levels, using Duncan's multiple range test (*9*), showed that only the nos. 4 and 1 were significantly different. The difference must have been caused by some factor other than the level of treatment. Therefore, it seemed justifiable to conclude that the ply interaction was not affected by the type of treatment of fibers nor by the magnitude of the treatment. The change in bursting energy due to a change in the number of plies may then be determined from the product of the single ply burst energy and the 1.514 power of the number of plies desired.

Now, if our previous findings are correct, this function should also describe the effect that changing the number of plies will have on the drop test. Data verifying this possibility may be obtained if we convert 3/40 and 4/40 sack test data to what they would be at a single ply applying the same ply interaction formula for both the drop test and the FRAG. Assuming that relations from a change in the number of plies can also be expressed for the drop test by the same equation:

$$S = AN^{1.514} \qquad (4)$$

where:

S = safe-inches of drop
N = number of plies
A = proportionality constant describing single ply quality

If we now plot the cubes of these converted single ply qualities, the same correlation should be obtained as that of the unconverted experimental data. It is shown in Fig. 5. The correlation was as good as the experimental data. The correlation coefficient was +0.951, and such correlation was 95% significant when measured by F ratio. The slope of the curve (the construction feature constant) was 0.187 as against 0.162 for the experimental data. The difference

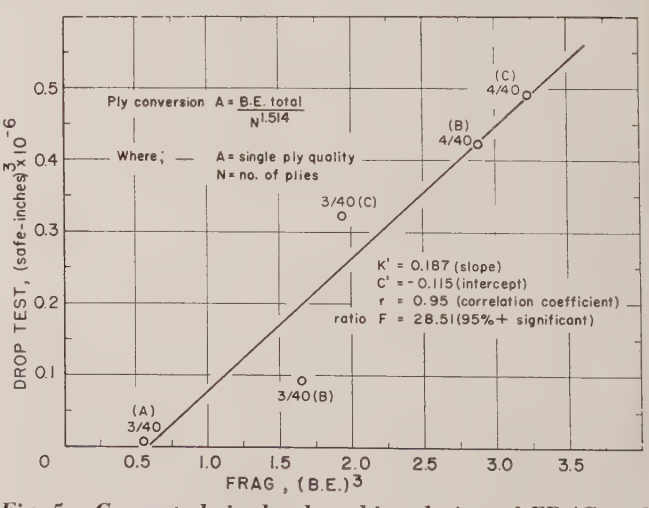

Fig. 5. Converted single ply cubic relation of FRAG and drop test of 3/40 and 4/40 SV sacks made from experimental curve

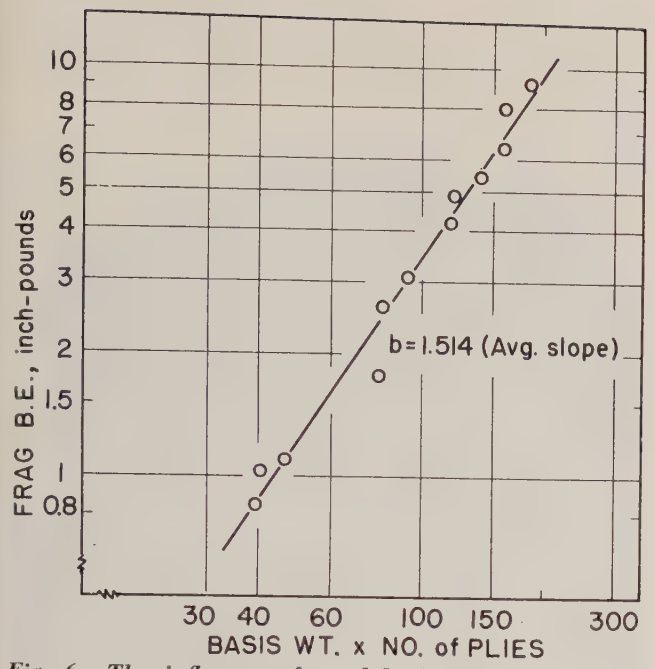

Fig. 6. The influence of total basis weight on FRAG burst energy

is only about 15% which could have been due to the use of the average ply interaction factor. Only a large number of such comparisons can verify statistically if there is any real difference between the two interaction slopes. However, since the discrepancy is within the magnitude of the relative dispersion found for both FRAG and drop tests, it can be assumed that interactions are similar. Therefore, one could reasonably assume that the ply interaction factor found from the FRAG test is essentially the same as in the drop test.

The ply interaction formula then becomes useful for predicting if a ply could be removed from a sack for a given strength improvement in the paper and still maintain the normal performance. The following rearranged ply interaction formula can be used:

$$A_2 = \frac{A_1 N^{1.514}}{(N-1)^{1.514}} \qquad (5)$$

where:

A_1 = burst energy; one ply
A_2 = burst energy; one ply new paper
N = number of plies in control construction

For example, if one wants to remove one ply from a four-ply construction, while maintaining the same performance, an improvement of at least 1.54 times the original paper's burst energy would be required.

Another use for the interaction formula is to see if a reduction in the sack's total weight of paper can be achieved. Here, the problem is to find a means for translating burst energy to an expression for a reduction in weight for a given improvement in paper strength. The relationship between burst energy and total weight, which includes the ply effect, is of the same form as used for measuring the ply interaction as shown by Fig. 6. It can be represented by the ply interaction formula, substituting total weight for the number of plies:

$$Y = A(WN)^{1.514} \qquad (6)$$

where

Y = burst energy
A = constant, describing paper quality
W = basis weight
N = number of plies used

Then the equation can be expressed in terms of the reduction in weight permitted by a given improvement in paper quality as follows:

$$W_r = W_1 \left[1 - \left(\frac{A_2}{A_1}\right)^{-1.514}\right] \qquad (7)$$

where:

W_r = permissible total weight reduction
W_1 = weight of control construction
A_1 = constant, describing control paper quality
A_2 = constant, describing improved paper quality

For example, a permissible weight reduction for an increase of, say 54% increase in burst energy over the original paper, would be about 24.8% of the original weight paper. In other words, an increase of 54% in the burst energy would be equivalent to a reduction of one ply or a reduction in paper weight of about 24.8%.

CONCLUSION

In practice both the FRAG and progressive drop test may be used to compare sacks made from different papers, but they may not be used interchangeably for sacks of different constructions.

The FRAG test may be used to compare different numbers and weights of plies to arrive at the most economical sack construction in a more reliable, quicker, and less costly manner than the drop test.

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APPENDIX

Derivation of the Relationship between the Drop Test and FRAG

It has been shown that the progressive drop test is related to the cube root of the constant height drop test for cartons (*8*). Using a similar approach, a mathematical formulation between the FRAG and the progressive drop test can be made. Starting from the function describing the experimental Wöhler curve:

$$Y = \frac{c}{(x-a)^2} \qquad (8)$$

where:

Y = number of stresses for drops from equal height until failure occurs
x = magnitude of the stress (corresponding to the changed height of drop)
a = critical height (limit of elasticity)
c = a constant

If one sets the number of FRAG drops to failure of the test specimen equal to B, then:

$$B = \frac{c}{(x_s-a)^2} \qquad (9)$$

where:

x_s = average magnitude of stress

The constant c is now defined as:

$$c = B\,(x_s - a)^2 \qquad (10)$$

The application of this equation to the progressive drop test is made possible by a summation which adds all the individual partial damages.

The final expression for the number of drops f in the progressive drop test for the progression of height and the increase in the magnitude of stress proceeds in gradual steps-of equal size d becomes

$$f = K\sqrt[3]{B + C} \qquad (11)$$

where:

$$K = 2.23\,\frac{(x_s - a)^2}{d^2}$$

$$C = \frac{2a - d}{2d}$$

or

$$f^3 = K^3(B + C) \qquad (11a)$$

Since the absolute bursting energy (E) of the FRAG test was defined as the cube root of the drop number:

$$f^3 = K^3\left[\left(\frac{E}{x_s}\right)^3 + C\right] \qquad (12)$$

or

$$S^3 = K'(E)^3 + C' \qquad (13)$$

where:

S = safe-inches of drop

$$K' = \frac{10.648d}{x_s{}^3}\,(x_s - a)^2$$

$$C' = K'C = K'\,\frac{2a - d}{2d}$$

The drop test, therefore, is directly proportional to the FRAG in their cubic relationship.

Coating Polymers for Paper Products

W. L. BOYER

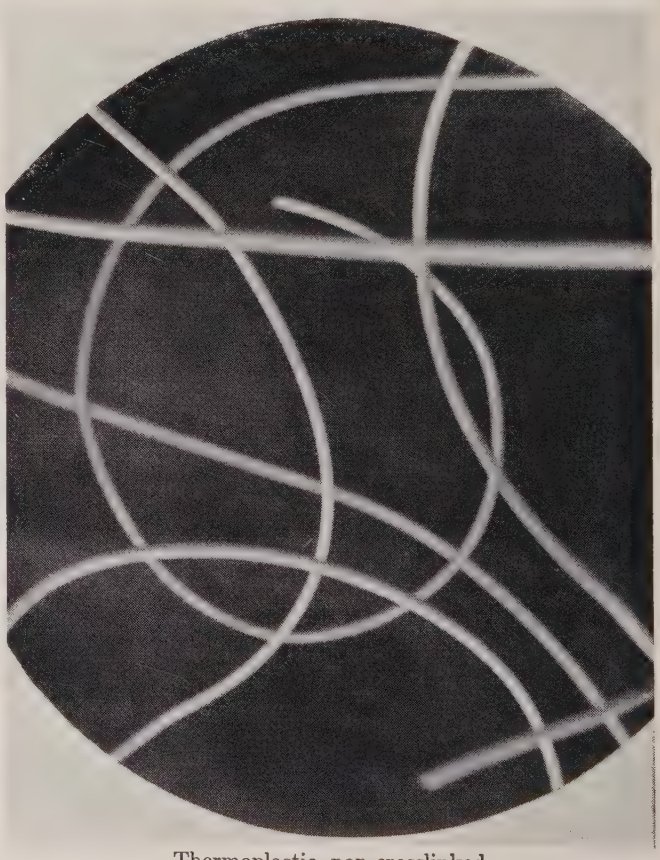
Film forming polymers are related, similar to our own living families, and their practical utilization requires only an understanding of their relationship to each other. Almost all paper coating polymers are in the Thermoplastic "clan." Polymers are formed by a linking of one (monomer) chemical unit to another to form a "Vertibre" chain (polymer). This presentation of the polymer families can become a "mental index" to help catalog the polymer children of the past, present, and future.

Polymers are a genetic group similar to our own human race in many respects. Almost all polymers and resins are built with the same "vertebra" of carbon, hydrogen, oxygen; with a few others, such as chlorine, nitrogen, etc. The similar chemical "anatomies" of most polymers could be misleading, if we were not already aware of their tremendous differences seen in everyday use. The determining factors are the many "vertebra" formations; they could be compared to the great variety of vertebrate species. Naturally occurring resins are usually more complex in their physiology, while new synthetic polymers are "joined" in carefully controlled simpler configurations.

The children of our polymer family tree can be divided into two characteristic types—thermosetting and thermoplastic. Thermosetting types form cross-linked lattices, which become rigid and immobile, even under the reapplication of heat. Thermoplastics are noncross-linked chains which are mobile and fluid under the reapplication of heat. Each type serves a definite purpose, meeting the exacting demands of our present day standards of living.

Figure 1 shows how these polymers might appear if we

Thermoset, crosslinked



Thermoplastic, non-crosslinked

Fig. 1. Polymer chains

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could see them as connected (cross-linked) and nonconnected (noncross-linked) chains.

A brief review of the polymer "family tree," Table I, will help to show their close relationships. This family tree can then become an index for the many details which escape mental cataloging simply because they so often seem to lack an apparent connection.

Table I. Polymer Family Tree

Thermosets	*Thermoplastics*
Drying oils	Casein, protein, etc.
Varnishes	Cellulosics
Alkyds	Polyethylene
Phenolics	Polyvinyl chloride
Polyesters	Polyvinylidene chloride
Epoxies	Polyacrylates
Isocyanates	Polyvinyl acetate
Amines	Polyamides
	Polystyrene

POLYMER TYPE

Thermosetting "Kin"

Thermosetting types have not found practical application in paper coatings to date; however, formulation and application developments indicate their possibilities for future paper coatings. The thermosetting type resins are converted through various chemical reactions to a cross-linked condition. These cross-links lock the chains into immovable positions so that heat will not cause them to be distorted (up to their degradation temperature). Drying oils, the first generation of this polymer family, are seldom recognized as thermosetting since they start from a liquid state, reaching a solid, irreversible condition, only after prolonged aging. Varnishes were the next generation, hard resins dissolved in drying oils to increase the "solids" and thus reduce the aging required to convert the fluid to a solid state.

More than 1000 years passed before the third generation appeared: alkyds. The machine age demanded exacting

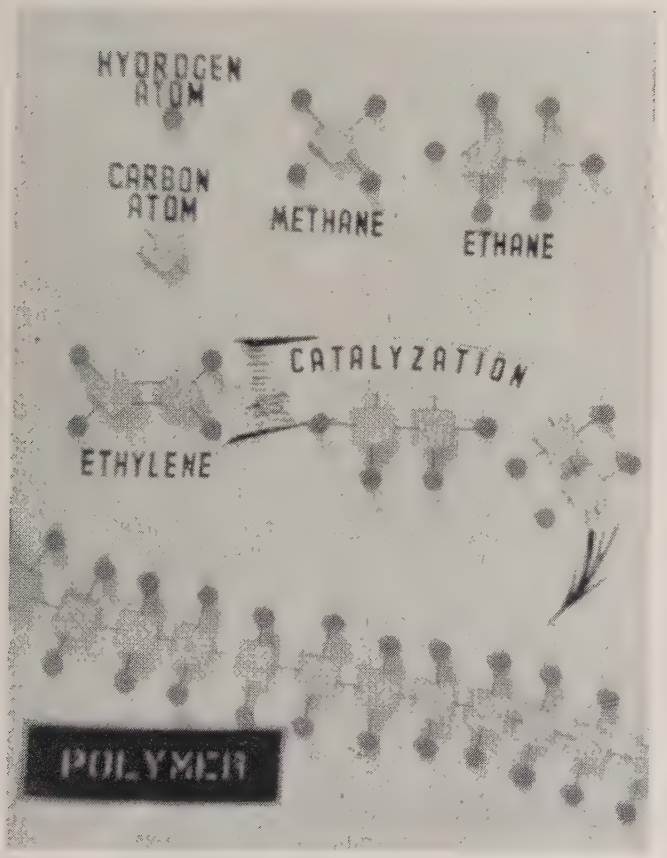


Fig. 2

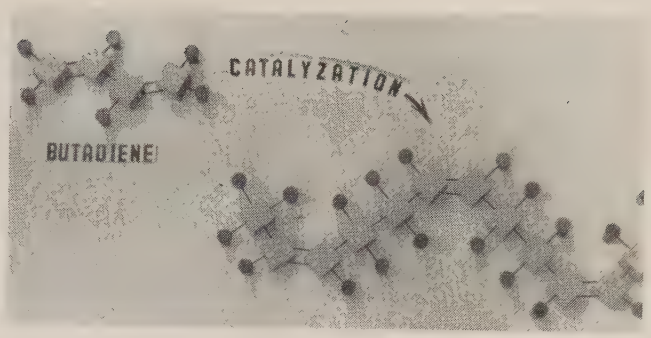


Fig. 3

requirements of application, drying, flexibility, hardness, and many more. Natural resins and oils could not survive this revolution, and the new "synthetic" generations were born. New synthetic resins have been appearing in all branches of the polymer family tree.

In the last 10 years, new polymer species have been appearing so rapidly that their family connections are not easily seen. Many new thermosetting "nephews" such as polyesters, epoxies, isocyanates, etc., are heat convertible, being used as coatings as well as physical forms.

Thermoplastic "Relatives"

Thermoplastic polymers have been known for many years; casein, protein, starch, etc., are part of this family. Pyroxlyn, the cellulose nitrate resin, was the basis for our widely used lacquers. Today, there are other cellulose "offspring" which serve more specific applications, replacing the nitrated cellulose to a considerable extent.

Thermoplastic chains are not connected by cross-links. This allows them to move when the temperature is raised. The absence of cross-link sections in the chains prevents changes in flexibility on aging, an important advantage. Chain lengths and branches can be varied to obtain specific properties, such as solubility characteristics. This also assures polymer films with exacting reproducibility.

POLYMERIZATION

A quick look at the way a polymer is formed will help show their close relationships. Polymers are formed by a chemical process called "polymerization." A number of types of polymerization are used for various polymers. Vinyl polymers are formed via "addition polymerization," and this type will serve to illustrate the chain formation process.

Addition Polymerization

Addition polymerization means exactly what the name implies—addition of one (monomer) chemical unit to another to form a link chain of many (polymer). The monomers, figuratively, open arms and link hands to form chains of controllable lengths. The simplest monomer is ethylene (Fig. 2).

Atoms combine to form molecules, the basic building blocks for all materials, natural or synthetic. The carbon atom always has four energy bonds which must hold to four other atoms. Hydrogen has only one. These energy bonds could be considered as small magnets. All energy bonds must be attached, none remain unsatisfied or free, under normal conditions.

A molecule, such as ethylene, with two hydrogen atoms less, must have two bonds between the carbons to maintain the four-bond linkage always required. Multiple bonds between carbons is unique because the bond can be opened (like "opening arms") with catalyzation to allow it to link with other molecules, thus forming a *polymer*.

Figure 3 is an example of a more complex linkage formed

Table II. Polymer Genetics

	Form (usual)	*Solubility*[a]	*Compatibility*	*Flexibility*	*Cohesion*[a]	*Water and chemical resistance*	*Applications*
			HOMOPOLYMERS				
Polyethylene	Resin	V. Poor	V. Poor	Good	Good	V. Good	Free film, paper lamination, molded articles.
Polyvinyl chloride	Resin & latex	Poor	V. Good	Good	V. Good	V. Good	Plastisols, paper coating (*Lx*) (*Lq*),[b] paper lamination, free films.
Polyvinylidene chloride	Resin & latex	Poor	Fair	Fair	V. Good	Good	Paper coatings (*Lx*), paper saturation, paper lamination, free films.
Polystyrene	Resin & latex	V. Good	Fair	Poor	Fair	Fair	Paper coating (*Lq*) (*Lx*), molded articles, rigid foams.
Polyvinyl acetate	Latex	Fair	Fair	Poor	Poor	Fair	Paper coatings (*Lx*), adhesives, paper saturant, wall paints.
Polymethyl methacrylate	Resin & latex	V. Good	Fair	Poor	Poor	Fair	Paper coatings (*Lx*) (*Lq*), wall paints.
			COPOLYMERS				
Styrene, 60–70%; butadiene, 40–30%	Latex	.....	Good[c]	V. Good	V. Good	Good[d]	Paper coatings (*Lx*), adhesives, paper saturant, wall paints.
Styrene, 90%; butadiene, 10%	Resin	V. Good	Good	Good	Good	Good	Paper coatings (*Lq*), house paints, cement paints.
Vinyl chloride, 85%; vinyl acetate, 15%	Resin	Fair	Good	V. Good	V. Good	V. Good	Paper coatings (*Lq*), inks for vinyl products.
Vinyl chloride, 75%; vinyl acetate, 25%	Resin	Good	V. Good	Good	Good	V. Good	Paper coatings (*Lq*), metal coatings.
Vinyl chloride; vinylidene chloride	Latex & resin	Good	Fair	Fair	Good	Good	Paper coating (*Lq*) (*Lx*), paper saturant.
Acrylate acetate	Latex	.....	Fair[c]	Fair	Poor	Fair[d]	Paper coatings (*Lx*), adhesives, seal coats, and wall paints.

[a] Molecular chain lengths will influence properties considerably, but copolymers will have the dominating influence.
[b] Lq = Lacquer system; Lx = latex system.
[c] Wetting agents (stabilizers) may cause initial incompatibility in latex system even though dried film ingredients are compatible.
[d] Suppliers of latex must incorporate wetting agents (stabilizers) to maintain a stable latex and these may reduce the properties of the final film; thus, coating of similar latexes from different suppliers may show property variations.

in the case of butadiene (and natural rubber); here two "linkage sections" are available in the same monomer. The 4-bond balance for carbon demands that a double bond remain in specific sections of the butadiene polymer.

A carbon-to-carbon "vertebra" is the most stable, while carbon-to-oxygen "vertebra" is more susceptible to chemical attack. Silicone substituted for the carbon in some chains forms a polymer which is extremely stable to heat. Some substitutes for hydrogen attachments to the carbon will change the stability considerably, i.e., fluorine will increase the stability.

All simple, straight-chain polymers, such as polyethylene, are insoluble. Chains can be controlled (short lengths) to improve the solubility, but this affects other properties, especially reducing the flexibility. To obtain increased solubility without sacrificing the other required properties, different type monomers are hooked into the same chain. Copolymers are chains with different monomers, while chains with the same monomers are called homopolymers. Some thermoplastics in commercial use today contain as many as four monomers in the chain. Obviously, this variety of monomer combinations for polymer chains holds a vast potential for "tailor made" properties in a resin.

Graft polymers are a recent development in which one polymer is made (usually a colloidal suspension in water) and another polymerization of entirely different monomers is formed around the first one. This method holds the potential of forming polymer chains with flexible centers and hard surfaces, etc. Additional polymerization possibilities seem to be inexhaustible.

POLYMER GENETICS

Table II, showing the most common polymers, will help to show their associations as well as their areas of practical application. The general characteristics shown are based on the polymer alone. Compounding ingredients will alter the film properties considerably, sometimes beyond the point of recognition of the original polymer. The polymers which have good compatibility for compounding ingredients are the most adaptable to a variety of applications, and these hold the best possibilities for future developments.

ADAPTION/APPLICATION

Development of a practical end use of these polymers will depend on the proper selection of the resin and compounding materials. Application requirements and finished product specifications usually reduce the choice of resins to only a few. But compounding ingredients are available in many varieties to help adapt the polymers to many requirements. Application methods are usually considered first in the selection of polymers.

Application Classifications

1. Solvent Systems
   (a) Water soluble resins in solution.
   (b) Lacquer solutions—drying through solvent evaporation.
2. Dispersion Systems
   (a) Latex—colloidal resin dispersion in water.
   (b) Plastisol—vinyl chloride resin mechanically dispersed in plasticizer.
3. Curing Systems (Reactive systems which require cross-linking to form optimum film properties)
   (a) Nonbaking types—varnishes, alkyds.
   (b) Heat convertible types—phenolics, polyesters, amines, alkyds, etc.
4. Hot Melt Systems
   Waxes, etc.
5. Free Film Systems
   (a) Extruded, calendered, cast—free films used without further processing.
   (b) Lamination—free films pressed on paper.

Paper coating applications are usually considered under the solvent systems (1) and dispersion systems (2). The others are used in paper application, of course, but are not generally considered as "coating" methods.

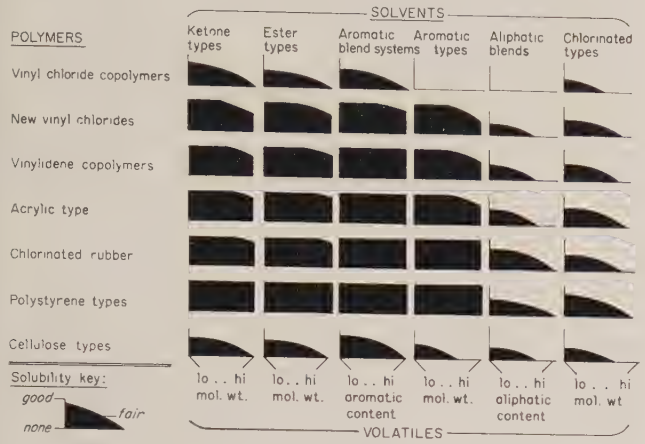
Considerable misuse of the words "paint" and "varnish" has confused these curing types with lacquer systems. Curing systems have not found many practical applications in paper

coatings and seem to have limited possibilities at present. Future equipment developments, as well as new polymer developments, may increase the possibilities for paper coatings based on curing systems.

SOLVENT SYSTEMS

Solvent (lacquer) systems dry by solvent evaporation alone, presenting the least problems of application with the greatest

Table III. Polymer Solubilities



adaptability for a variety of application conditions. Availability of a large variety of solvents increases the probabilities of successfully formulating these lacquers, with a minimum of developmental work. Definition of terms is necessary before we can discuss these "lacquers" properly.

Solvent—A liquid, usually volatile, capable of dissolving a specific resin (even water becomes a solvent when the resin is water soluble).

Diluent—A liquid, usually volatile, which will not dissolve a specific resin but can be tolerated in the presence of a solvent. In some cases a diluent may even improve the solvency of a system.

Dispersant—Used to wet pigments, resins, etc., to improve manufacturing processes.

Stabilizer (Solution)—Propylene oxide, epichlorohydrin, are typical examples having the well-known property of absorbing and "tieing up" free chlorine. This is essential in all lacquers made with resins containing chlorine.

Coupler—Usually alcohols which help reduce the viscosity of a cellulose solution, in a solvent system of ketones and aromatics. They are not solvents or diluents.

Naphtha—A loosely used word having many meanings. Generally means a mixture of petroleum volatiles, predominately aliphatics.

Plasticizer—Nonvolatile solvents, available as monomeric and polymeric types.

Polymer Solubilities

The polymer solubilities chart (Table III) lists some of the polymers which seem to show the best possibilities for paper products. Better solubility is indicated by larger shaded areas. Insolubility is indicated if no shading appears in the area. The solvents (volatiles) are differentiated, in general, by the descriptions at the bottom of the columns. A low (lo) molecular weight ketone might be acetone and a high (hi) one, cyclohexanone. Solvent blends have low (lo) and high (hi) proportions of one indicated.

This general description can only indicate polymers which might be useful, so that development work can proceed from that point.

Low molecular weight solvents show maximum solvation characteristics. A single solvent is seldom used in a lacquer system. Blends are necessary to balance the requirements of solids, viscosities, evaporation rate, flammability limits, odor, and especially economics. The polymer which is soluble in a large variety of solvents is not necessarily the best; a typical example is the highly soluble polystyrene. Such coatings cannot be overprinted without causing considerable softening; and, in addition, plasticizer migration is always a threatening problem. These highly soluble resins will absorb plasticizing ingredients from other surfaces which are softened beyond usefulness by this migration of plasticizers.

Polymers finding the most frequent successful applications are those with very specific solubilities. A very general rule of "like dissolves like," finds its limited plausibility in the "polarity"; polar solvents are usually the best solvents for polar resins. Specific application methods require some background of the resin/solvent characteristics if the polymer coating is to be used without excessive recurrences of problems.

Different polymers can be formulated to meet the same end product specifications, but each polymer will require different compounding ingredients. Fortunately, formulating ingredients are available in tremendous variety, assuring successful adaptation of a variety of polymers for a specific paper product.

DISPERSION SYSTEMS

Plastisol

Plastisols are unique dispersion systems; a polyvinyl chloride resin mechanically dispersed in a plasticizer. The plasticizer (liquid) acts as the vehicle, until the system is raised to a temperature in the range of 350°F., then solvation occurs. On cooling, the solution gels, becoming tough and rubbery. Formulation of the plasticizers is similar to the solvent-diluent relationship for solution resins. A delicate balance must be maintained to avoid solvation at room temperature, but complete solution must occur at the bake temperature. Plastisols are effectively 100% solids since no volatilization occurs. The unusual viscosity characteristics of plastisols require special application techniques. Plastisol viscosities, as well as high baking temperature requirements, have limited applications for paper products, but some successful paper coatings are in production.

Latex (Emulsions)

Latex (emulsion) is a colloidal suspension of a resinous particle in water. The particle will not remain in a stable suspension unless it is small enough to be in Brownian move-

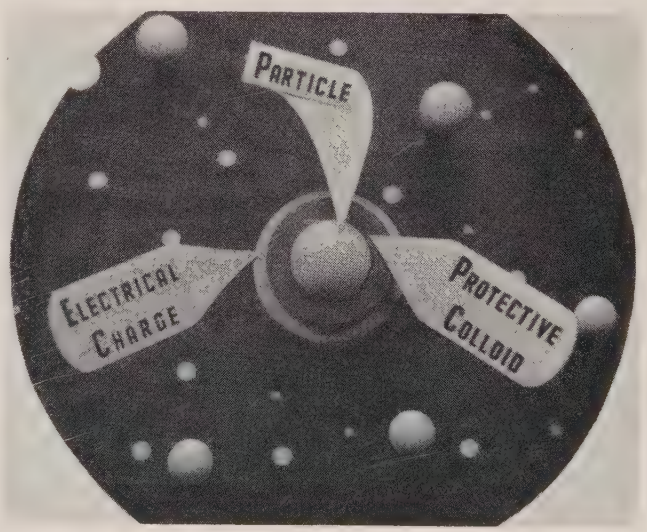


Fig. 4

ment, and have a protective "envelope" as shown in Fig. 4. The protective colloid can be a soap, thickening agent, and similar materials. The electrical charge layer is usually negative, generally obtained with the addition of a base, such as sodium hydroxide, or ammonium hydroxide.

Latex has been known for many years as the sap from the rubber tree, and lately as a vehicle for water-based paints. Coatings based on water-soluble resins are not new to the paper industry. Attempts to reduce water solubility after drying were never very successful; however, development work along this line is always in progress. With the latex systems a water insoluble resin is in colloidal suspension, and the film formed can be insoluble. The advantages of the latex system are: nonflammable, nontoxic, low odor, water cleanup, 50% vehicle solids at water-thin viscosities, and high polymer systems (solvent insoluble).

The advantage of water cleanup of equipment and low odor was the cause for the latex replacement of oil for interior wall paints during the past, brief 10 years. In the next 10 years, we will find the other advantages more important, as the latex system is adapted to industrial applications. Most work to date has been done with room temperature coalescent latexes, but elevated temperatures can be used with some latexes to form films as tough as "vinyl upholstery sheeting."

The disadvantages of a latex system cannot be minimized if we are to take full advantage of this potentially ideal system. To maintain a latex in a stable system water soluble materials must be used. Even though they are used in small percentages, they can cause complete failure of the film. Too often this failure is misinterpreted as the latex binder failure. This is the area of research most essential for the development of successful latex coatings. Unfortunately, slow recognition of the critical influences of these "minor" components in the latex has caused failures in some commercial applications. The future success of latex coatings will depend on our effort to identify and solve these problems related to the "minor" components.

Latex systems are the most significant coating developments since the discovery of drying oil systems. The successful utilization of the latex is only limited by the ingenuity and persistent work of formulators. We are fortunate to be present in an age when we will have the opportunity to help "rear" this new race.

FUTURE "GENERATIONS"

Coating polymers (resins) are available in tremendous variety today; but tomorrow there will be many more. Those who do not attempt to determine the place of each new polymer in the family tree, may find the future becoming very confusing. These new polymers hold tremendous potentials, since their properties can be made-to-order for the specific tasks.

Economics are always a factor in the practical utilization of materials, and one of the limiting factors for some of these new polymers. But the cost of these polymer films should be reduced considerably, if more than one-half of their film thickness is replaced by paper. In many instances a paper substrate adds unique properties which would not have been available with the polymer film alone. Impregnation and saturation applications of these new polymers have unexplored future possibilities as well.

Paper developments and the resulting paper consumption in the past 20 years have been phenomenal and, to a large extent, without the help of the new polymers. With the marriage of paper and coating polymers, the next 10 years will be more than a honeymoon; it will become a whole new family tree of paper/polymer "generations." They will be so different from either the paper or polymer "children" we know today that bibliographies and genetics reviews will have to be regular and frequent events if we are to keep in touch with all the "relatives." Through the science of adaptation and application, these new generations will bring us new standards of living and, undoubtedly, new ways of life.

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Dispersion of Asphalt Materials in Paper Stocks

L. C. VAN GUELPEN

This paper covers, in general, the problems encountered by a paper or board mill whose principal furnish is waste paper. Since a great percentage of this waste paper contains asphalt, in some form, this study deals with the difficulties arising from its presence. Unsuccessful methods of eliminating the asphalt are touched on briefly, and how the present method of diffusion was devised. A description of how diffusion is accomplished will be given with figures showing why this method is economically sound. This topic concerns the Petro-Diffusion system, its method of operation, type of equipment used and how system is controlled automatically.

Since the paper industry first began using asphalt as a moisture seal, troublesome and costly problems have confronted paper mills whose principal furnishes are wastepapers and waste corrugated.

Even the best known methods of slushing, cleaning, and refining cannot sufficiently dispel the agglomerated asphalt to produce a satisfactory end product. The use of solvents has proved too costly, and the investigation of absorptive materials has not been successful to date.

The resultant product of the normal stock preparation approach, at normal stock temperatures, is a sheet which is very difficult to market due to poor appearance.

In addition to poor sheet quality, asphalt and other thermoplastic materials entrained in the sheet cause many operational difficulties on the paper machine, printing presses, corrugators and slotters. Wires tend to plug, felts clog; and press, drier and calender rolls gum up. Down time for cleaning naturally results in a poor production record.

In order to eliminate these problems, board mills have been forced to buy costlier furnishes. Under and back liner stocks of better quality and heavier calipers are required to cover asphalt spots in the filler stock.

The paper mills, too, have had to purchase more costly raw materials for their fourdrinier grades. In addition to their own problems with asphalt, there are also complaints from the converters.

Operational difficulties on printing presses are obvious. Remelting of the entrained asphalt at the corrugator and even the plugging and sticking at the slotters are equally perplexing.

Many methods have been tried to eliminate the asphalt in reclaimed paper and corrugated furnishes. The problem became so great that a group of paper mills joined together in the formation of a Fibre Conservation Corp. These mills contributed large sums of money to research conducted by The Institute of Paper Chemistry in Appleton, Wis. After much time and money had been spent, it was found that instead of trying to remove asphalt from the furnish, it could be dispersed within the sheet itself, into such minute particles that it no longer became troublesome.

ASPHALT DIFFUSION—HOW ACCOMPLISHED

Natural asphalt used in the paper industry has a melting point of 280 to 290°F. Lower melting points are reported and sometimes are indicated as low as 160°F., but this is merely softening, rather than melting; or the fluid point necessary for diffusion.

At the 290°F. temperature, the asphalt reaches its fluid state which is the best condition for diffusion. To achieve this in a system, the stock slurry is raised above the melting

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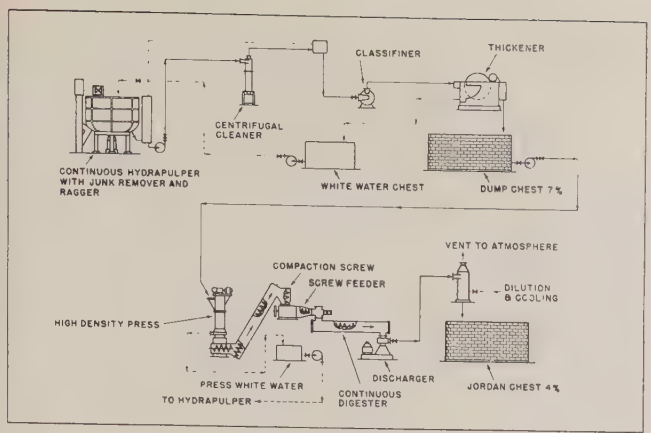

Fig. 1a. Stock preparation and Petro-Diffusion system

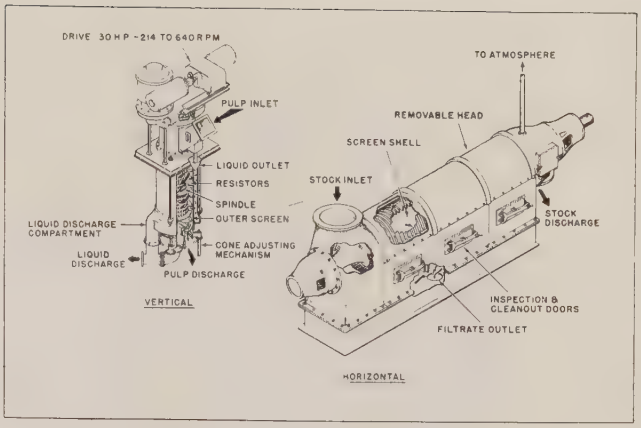

Fig. 2. High density presses

point of asphalt, so that the oils and tars present in the asphalt are partially vaporized—leaving only a carbonized sediment to be diffused with the fibers.

This process is rarely attempted at low consistencies because of prohibitive steam costs. For instance, at 5% consistency, there are 39,000 lb. of water per ton of fiber. To heat this water from 110 (normal stock system temperature), to 305°F. would require 7,605,000 B.t.u. At 40% consistency, there would only be 5000 lb. of water. To heat this from 110 to 305°F. would require 975,000 B.t.u. The fiber has a specific heat of 0.37 and would require 144,000 B.t.u. in each case. We have found that the most economical operation is obtained where the stock is discharged from the high density press at a consistency of 32 to 35%.

PETRO-DIFFUSION SYSTEM

Long aware of the existing need for an efficient asphalt dispersing system, which could be installed for less capital investment as well as low applied horsepower costs, Black-Clawson engineers have designed, developed, and built a commercial size system. This system comprises stock preparation equipment manufactured by the Shartle Division, combined with the Chemipulper continuous digester equipment of the Pandia Division.

Because of the apparent efficiency of this system in not only dispersing, but rather the diffusing of minute asphalt particles into the fiber mass, the name Petro-Diffusion system was chosen.

The first commercial system (Fig. 1a) was put into operation by the Federal Paperboard Co., ahead of their bogus nine-point machine at Steubenville, Ohio. The second system (Fig. 1b) by the Elk Paper Co., Childs, Md.

Using the knowledge that only thoroughly slushed and diluted stock can be well cleaned, a continuous Hydrapulper complete with junk remover and ragger is used to slush the waste furnishes. The stock from the Hydrapulper enters the regulating box where it is diluted to 1% consistency and pumped to the liquid cyclone centrifugal cleaners, at a pressure of 35 p.s.i. At the centrifugal cleaners, foreign material with a higher specific gravity than the fiber is removed. The stock is then discharged from the centrifugal cleaners to a headbox. In this headbox, the flow to the thickener—and overflow back to the Hydrapulper regulating box—is controlled from the system control panel. At the thickener the stock is thickened to 8% consistency prior to entering the Petro-Diffusion system. The system contains a Black-Clawson high density press (Fig. 2) which dewaters the incoming slurry and discharges at a consistency of 32%.

From the vertical high density press (Fig. 2), the stock is conveyed by a vertical lift conveyor to the compaction screw which thrusts the stock downward into the continuous screw feeder (Fig. 3). The horizontal press (also shown in Fig. 2) used on high tonnage systems, requires no conveying equipment. At the screw feeder, stock is further compacted to form a stock plug in the throat which maintains steam pressure within the continuous digester tube (Fig. 4). For additional safety, a stop valve (Fig. 5) at the inlet of the tube prevents a blowback in the event of stock failure to the screw feeder. This is accomplished by a low limit amp switch which closes the valve when a low load is reached on the screw feeder drive motor.

Steam is introduced into the continuous digester at a pressure of 72 to 75 p.s.i. This pressure raises the temperature of the slurry above the melting point of asphalt. Although this moderately high pressure is used, steam consumption is not excessive (Table I Steam Consumption Chart). The continuous digester has an adjustable speed drive to control the dwell time of the stock in the tube so that the inherent oils in the asphalt can be vaporized and the resultant carbonized asphalt can be dispersed within the fibers themselves. At the

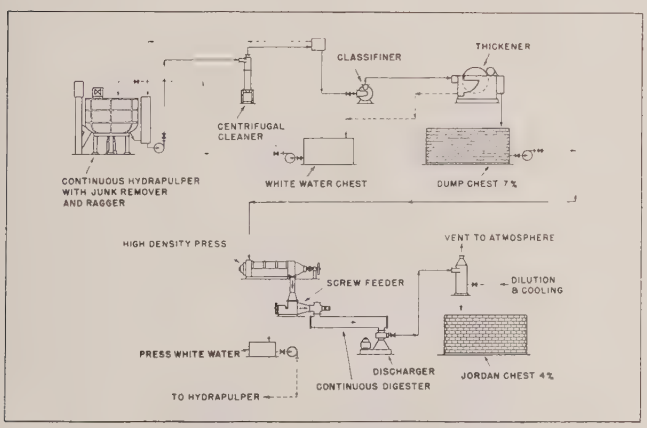

Fig. 1b. Stock preparation and Petro-Diffusion system

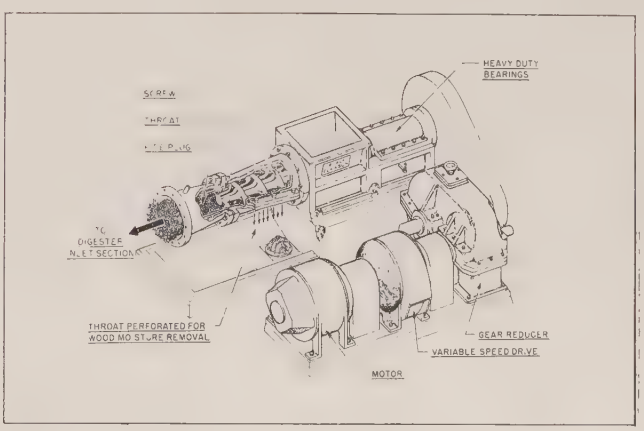

Fig. 3. Screw feeder

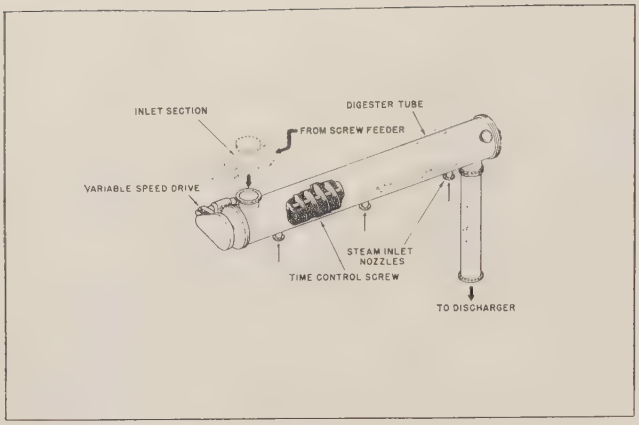

Fig. 4. Digester tube

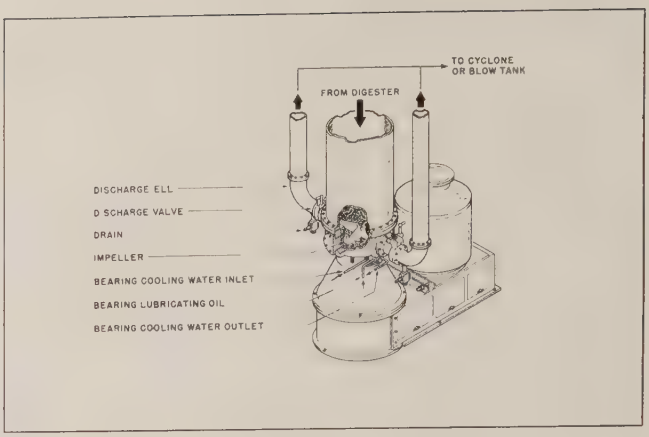

Fig. 6. Continuous discharger

discharge end of the continuous digester, the stock enters the inlet of the discharger (Fig. 6). This unit has two functions. It prevents the stock, discharged from the digester tube, from bridging as it is blown to the cyclone, and wipes the face of the discharge valve clean. This is accomplished by the rotating wiper arms that are located in the upper housing of the unit.

Connected to the discharger valve (Fig. 7) where the actual diffusion takes place. This is accomplished by the fiber passing from the high pressure cell of the discharger, across the valve, to the low pressure side of the discharge pipe; thus, expanding each individual fiber. As this is done, the entrained carbonized asphalt actually penetrates the fiber and becomes well diffused. This is accomplished without any fracturing of the fiber.

Figure 8 are photomicrographs of the fibers; (8a) prior to entering the discharge valve, and (8b) immediately following the valve. The apparent physical change is readily noted in the expansion of the individual fibers in the allowing the carbonized asphalt particles to penetrate.

From the discharge valve, the stock is blown into a cyclone where the steam and entrained vapors are discharged to atmosphere. At this point, cooling and dilution water is added so that the stock discharges into a chest at the desired consistency and temperature.

CONTROL

The items of equipment fitted with variable speed drives, namely the press, screwfeeder, and digester tube have their speed control mounted in the control panel. This panel contains the automatic steam pressure control in the form of a recording meter. The meter also records the temperature of the digester tube by means of a temperature bulb located in the tube. In this way, an accurate account of steam consumption can be kept.

In addition to the instrument just mentioned, the panel contains all of the start-stop buttons, as well as trouble lights and warning buzzer. These safety features are added to first, call the operator's attention to the panel, and then to the particular piece of equipment in trouble. A reset button is mounted to silence the buzzer when trouble is located. To further protect the system, the controls are set up in cascade fashion. In this way, the equipment above the trouble spot will stop in sequence so that the down machine is not overloaded with stock.

For instance, should the digester tube motor become overloaded, the ammeter on the panel with its high load contact would kick out the tube motor. To prevent the screw feeder from compressing stock into the inlet chamber of the tube, the cascade controls would shut this unit down. In like sequence, the stop valve would close. Then the high density press and the dump chest pump would be stopped; however, the discharger would continue to run unless stopped manually.

After the trouble has been corrected in the tube, its motor may be started. Then in series, the screw feeder, press, and pump.

Table I. Petro-Diffusion system

Steam Consumption
Stock consistency, 32 to 35%; Steam pressure, 75 p.s.i.g.

Tons/day	*Max. lb./day*	*Max. lb./hr.*	*Max. lb./ton*	*Connected hp/t/d*	*Consumed hp/t/d*
50	86,750	3,610	1735	2.4	1.16
100	172,800	7,200	1728	1.5	0.94
150	260,700	10,850	1738	1.7	..
200	348,400	14,550	1742	1.7	..

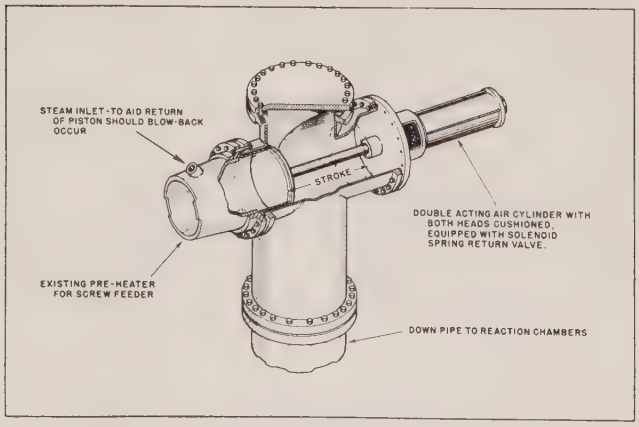
STEAM INLET-TO AID RETURN OF PISTON SHOULD BLOW-BACK OCCUR
STROKE
DOUBLE ACTING AIR CYLINDER WITH BOTH HEADS CUSHIONED, EQUIPPED WITH SOLENOID SPRING RETURN VALVE.
EXISTING PRE-HEATER FOR SCREW FEEDER
DOWN PIPE TO REACTION CHAMBERS

Fig. 5. Stop valve

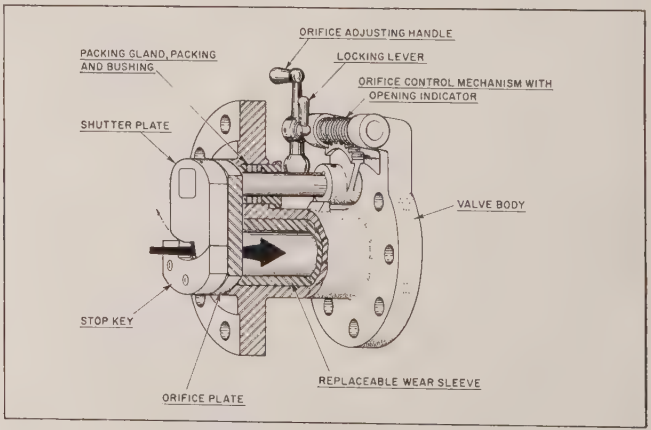

Fig. 7. Discharge valve

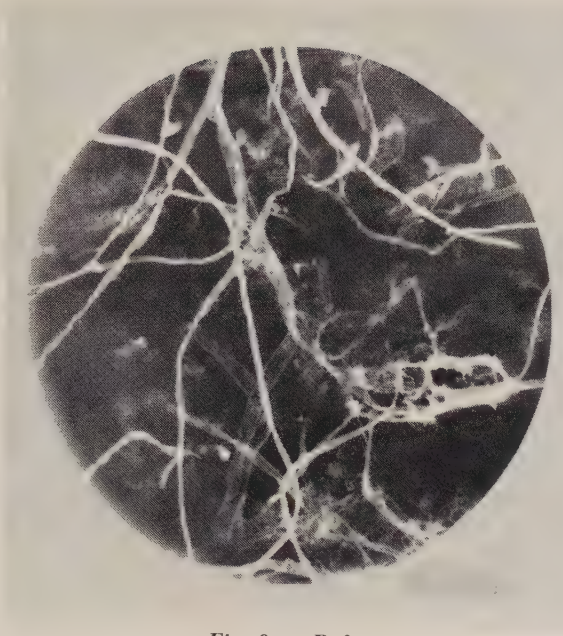

Fig. 8a. Before

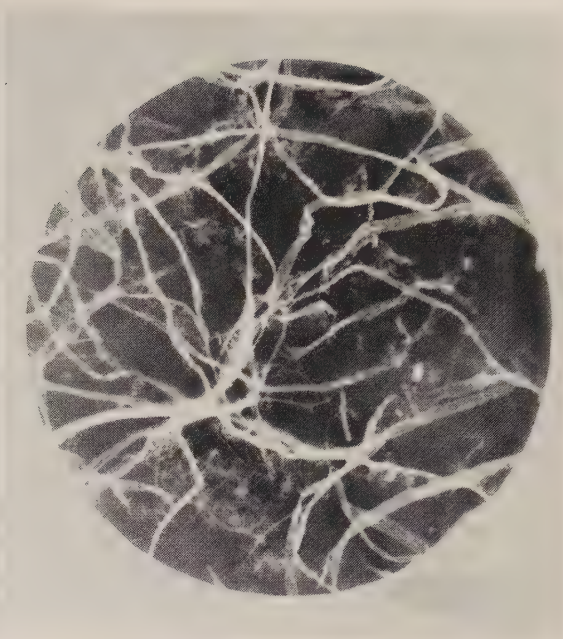

Fig. 8b. After

A sequence for starting up the system would go in this manner.

1. The system selector switch is placed in manual position.
2. The high density press, then dump chest pump follows.
3. The screw feeder motor is then started.
4. When the press starts to discharge stock to the screw feeder, its clutch button is jogged until a sufficient plug is built in the throat of the screw to open the stop valve.
5. The digester tube is then started, and the clutch button on the feeder is pushed to the "on" position.
6. The oil pump motor on the discharger is started, and the discharger valve is set to its predetermined opening.
7. The discharger motor is then started and the system is running in manual position.
8. When the required load is indicated on the discharger ammeter, the selector switch is turned to the automatic position. When this is done, the cascade interlock system is engaged.

Should a blowback occur while running, the load on the screw feeder motor decreases. The ammeter needle swings to a low point making contact with the adjustable low load contact on the ammeter. This trips the interlock and alarm circuits which causes the stop valve trouble light to flash, the buzzer to sound and stop the screw feeder, high density press, and stock pump. The digester tube, discharger, and oil pump would continue to run.

Whenever the screw feeder is stopped by means of other drives stopping the screw feeder through the interlock system, the stop valve will close.

CONCLUSION

Since it seems apparent that asphalt in some form is with the paper industry to stay, more mills will be forced into two methods of operation.

The first group who feel that the expenditure is too great to install a Petro-Diffusion system will be forced to either go to a more costly furnish for their paper and board or sell at a reduced rate to less discriminating converters. In both cases, this loss of income to the mill is apparent. In most cases, these mills could afford a system if they would sit down and figure these losses over a two-year period.

The second group will balance the cost of installing a new system against lost profits for higher costing furnishes or reduced income from under standard paper. These mills will not only find they can afford to install a system for diffusion, but will reap the reward since they will be the ones setting the standard for the industry.

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Viscose Grade Pulps from Sawdust of Loblolly Pine and Gum

KARL LAUER and H. CHAO-WU

Suitable viscose-grade pulps were obtained from sawdust of loblolly pine and gum by prehydrolysis–sulfate treatment. Filterability was in all cases satisfactory. Spinnability could be attained only by defibration of the prehydrolyzed sawdust. Pulps from nondefibered sawdust showed a remarkably lower uniform distribution of the D.P. than pulps from defibered sawdust.

The object of this study was to determine the suitability of sawdust for the production of viscose-grade pulps. A previous investigation (*1*) revealed that the greatest obstacle to the utilization of sawdust from loblolly pine or from gum is the irregular removal of lignin. Even if the sawdust is screened and only the coarser fractions are used, considerable losses as fines, passing a 100-mesh screen, occur. Microscopic analysis of strained fibers shows clearly that the pulps obtained are mixtures of fibers of varying degree of delignification. Lignin determinations on classified fractions confirmed that the lignin content increased with fiber length. As for both raw materials used, sawdust from loblolly pine and from gum, prehydrolysis–sulfate pulping was indicated the main objective became the preparation of the sawdust for cooking.

EXPERIMENTAL

Chemical and physical analysis were done according to TAPPI Standard methods.

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Table I. Analytical Data* of Raw Materials Used

	Loblolly pine		Gum	
	Chips	*Sawdust*	*Chips*	*Sawdust*
Moisture, %	28.5	22.2	24.7	16.5
Hot water extn., %	6.8	7.1	6.0	5.2
1% NaOH extn., %	20.0	19.4	19.2	18.6
Alcohol–benzene extn., %	1.90	1.74	1.40	1.38
Lignin, %	28.44	28.16	18.75	18.30
Pentosans, %	13.70	12.44	25.84	26.42
Ash, %	1.31	1.22	0.89	0.24

* All determinations calculated on extracted, moisture-free wood.

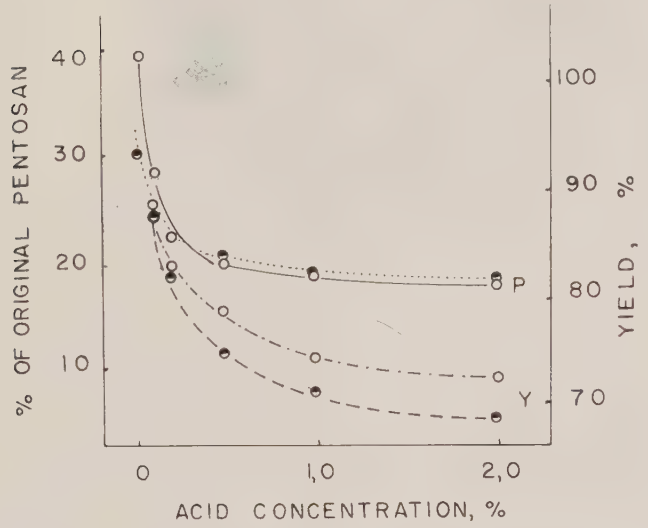

Fig. 1. Influence of acid concentration in prehydrolysis on yield (Y) and dissolution of pentosans (P), using 5 volumes H_2SO_4 at 125°C. for 3 hr.

pine, hardwood.

Table III. Influence of active alkali and sulfidity upon yield and permanganate number

Prehydrolyzed and defibered pine sawdust

	P-2	*P-3*	*P-4*	*P-5*	*P-6*
Wood:liquor ratio	1:4	1:4	1:4	1:4	1:4
Active alkali, % Na_2O	20.0	18.0	22.0	20.0	20.0
Sulfidity, %	18	18	18	15	25
Time to 163°C., min.	90	90	90	90	90
Time at 163°C., min.	150	150	150	150	150
Yield of screened pulp on wood, %	30.6	33.3	29.9	31.0	30.4
Permanganate no.	5.2	8.7	5.3	6.0	5.1

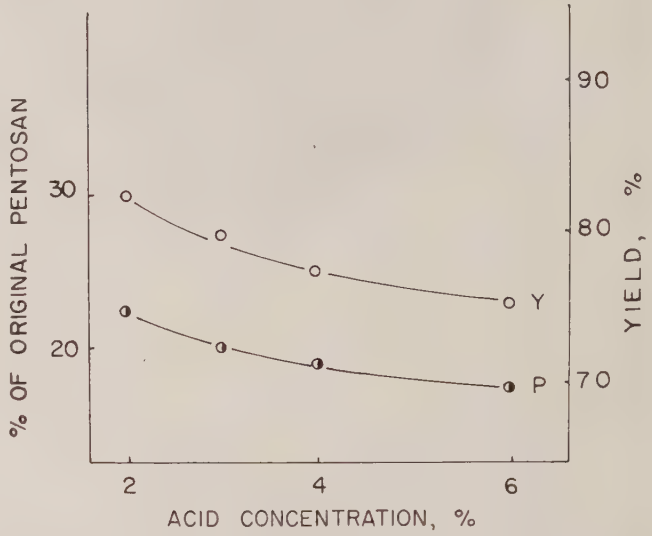

Fig. 2. Influence of acid:wood ratio (Pine) on yield (Y) and pentosan dissolution (P) with 0.5% H_2SO_4 at 135°C. for 3 hr.

Materials

Fresh sawdust was collected from a local saw mill and kept in closed containers, after a commercial fungicide had been added. The sawdust was screened and the fraction kept between screens of 10 and 28 mesh, about 75% of the original sawdust, was used. From the same trees millsize chips were prepared for comparison. Analytical data are given in Table I.

Acid Prehydrolysis

The object of prehydrolysis is removal of the largest possible amount of hemicelluloses. Preliminary experiments with 10 g. sawdust in steel bombs showed that 3-hr. treatment with 5 volumes of 0.5% H_2SO_4 at 135°C. gave satisfactory results. The influence of acid concentration, acid ratio, time, and temperature is shown in Figs. 1, 2, 3, and 4.

Screening of the prehydrolyzed sawdust through a 100-mesh screen showed that practically no fines, produced by prehydrolysis were lost. Under the microscope the presence of few isolated fibers was established besides fiber bundles as the main constituent. The most remarkable observation with both kinds of sawdust was the fact that a limiting value of removal of about 85% of the originally present pentosans is reached, after which only a parallel decrease in yield results. Final working conditions and results are compiled in Table

Table II. Acid Prehydrolysis and Sulfate Pulping

	P-0*	*P-1*	*P-2*	*G-0*	*G-1*	*G-2*
			Prehydrolysis			
Wood:liquor ratio	1:6	1:5	1:5	1:6	1:5	1:5
H_2SO_4 concn., %	0.5	0.5	0.5	0.5	0.5	0.5
Time to 135°C., min.	40	40	40	40	40	40
Time at 135°C., min.	180	150	150	180	135	135
Defibered	...	...	...	...	...	...
Yield, %	86.2	81.4	79.7	82.3	75.3	72.6
Pentosans in residue, %	4.8	3.5	3.5	5.7	5.0	4.9
			Sulfate Pulping			
Wood:liquor ratio	1:4	1:4	1:4	1:4	1:4	1:4
Active alkali, % Na_2O	22.0	20.0	20.0	20.0	20.0	20.0
Sulfidity, %	18	18	18	18	18	18
Time to 163°C., min.	90	90	90	90	90	90
Time at 163°C., min.	210	180	150	180	180	150
Yield of screened pulp on wood, %	37.8	32.1	30.6	34.7	30.5	29.2
Rejects, %	1.6	0.0	0.0	1.8	0.0	0.0
Permanganate no.	4.8	5.3	5.2	6.2	5.7	5.7
Lignin, %	1.14	1.51	1.25	1.68	1.45	1.40

* P = pine; G = gum; 0 = chips. 1 = sawdust; 2 = sawdust defibered.

Table IV. Bleaching

	P-0	P-1	P-2	G-0	G-1	G-2
Chlorine consumed, %	4.68	3.28	3.20	5.22	3.72	3.54
Yield on wood, %	33.8	30.4	28.1	31.9	27.6	24.8
α-Cellulose, %	93.4	93.8	94.2	93.7	95.3	94.9
β-Cellulose, %	2.4	1.9	2.2	2.9	2.1	2.5
γ-Cellulose, %	4.2	4.3	3.6	3.4	2.6	2.6
Lignin, %	0.08	0.09	0.10	0.09	0.14	0.08
Pentosans, %	3.6	2.7	2.7	3.2	1.9	2.3
Ether soluble, %	0.08	0.10	0.07	0.09	0.04	0.04
D. P.[a]	890	840	860	910	890	900
Filterability ml. per sq. cm.	635	616	645	519	538	525
Ash, %	0.12	0.06	0.04	0.09	0.09	0.04
Ca, p.p.m.	40	42	38	40	41	39
Fe, p.p.m.	2	4	3	3	4	4
Cu, p.p.m.	2	2	1	1	2	2
Mn, p.p.m.	0.1	0.1	0.1	0.1	0.1	0.03
SiO_2, p.p.m.	33	43	40	42	27	39

[a] 0.5% CED-TAPPI.

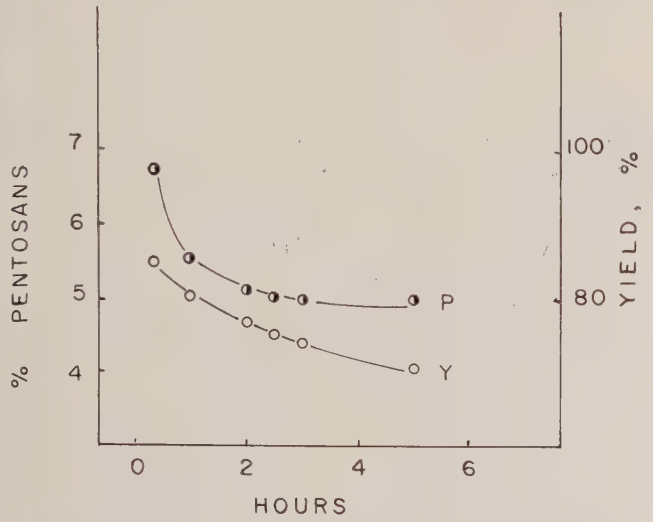

Fig. 3. Influence of time of prehydrolysis with 5 volumes 0.5% H_2SO_4 at 135°C. upon yield (Y) and pentosan dissolution (P)

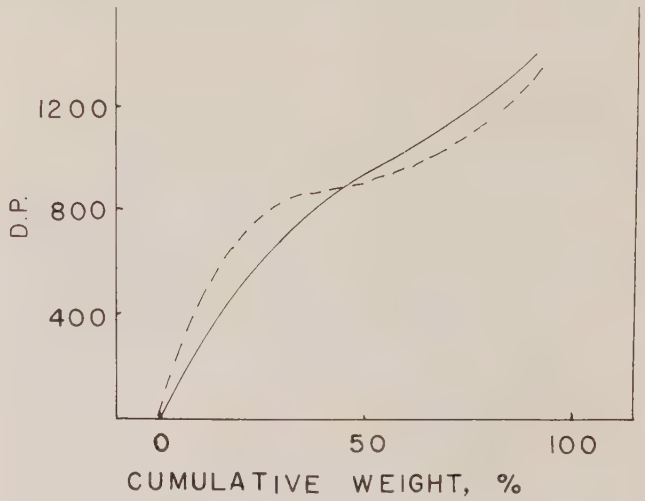

Fig. 5. Fractional precipitation of nitrated pulps —— nondefibered; ---- defibered after prehydrolysis.

II. It proved necessary to introduce a defibration step after prehydrolysis in order to obtain bleached pulps with a uniform D.P., as will be discussed later. The prehydrolyzed sawdust was washed and defibered at 2% consistency in a Bauer defibrator.

Sulfate Pulping and Bleaching

Cooking was carried out in a rotary, electrically heated, stainless steel digester. The pulp was blown and then washed at 60°C., and screened over a 0.15-mm. slotted screen.

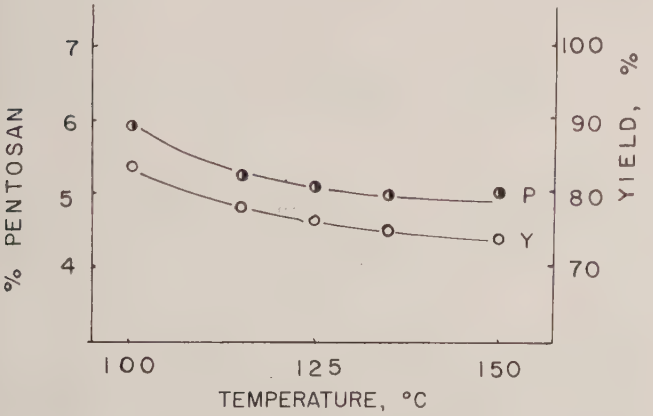

Fig. 4. Influence of prehydrolysis temperature upon yield (Y) and pentosan dissolution (P) with 5 volumes 0.5% H_2SO_4 for 3 hr.

A conventional three-step bleaching was applied, consisting in chlorination (3% consistency) with 90% of the chlorine demand at 20°C.; alkali extraction at 80°C. with 4% NaOH (5% consistency) at pH 10.6; followed by a sodium hypochlorite step (8% consistency) 25°C. and pH 8.5.

Using prehydrolyzed sawdust or chips, pulping conditions were varied. An increase of active alkali or a change in sulfidity from the data in Table II did not influence pulp quality, as seen from Table III. Shorter heating time to temperature resulted in more irregular removal of lignin, especially when chips were used.

Comparing data in Table II, the most remarkable observa-

Table V. Viscose solutions and filaments

	P-0	P-1	P-2	G-0	G-1	G-2
α-Cellulose in viscose, %	8.0	8.0	8.0	7.8	7.8	7.8
NaOH in viscose, %	7.2	7.2	7.2	7.1	7.1	7.1
γ-value of Xanthate	5.1	5.0	5.1	4.9	5.0	5.0
Hottenroth ripening degree	8.5	8.7	8.7	9.1	8.9	8.9
Filterability ml. per sq. cm.	475	480	460	395	380	386
Spinning viscosity, sec. per 20°C.	55	58	59	60	58	59
Maximum stretch, %	85	75	88	85	70	85
Filament denier	2.25	2.41	2.21	2.18	2.53	2.20
Tenacity g. per denier	2.06	1.73	2.01	1.96	1.68	1.98
Elongation at break, %	14	23	16	12	19	15
Swelling after conditioning, %	86	94	82	90	103	87
D.P.	345	356	342	342	326	335

tion is the difference in time-at-temperature for each group of wood in order to obtain pulps of similar permanganate numbers and lignin contents. With chips longer cooking times are necessary than with sawdust. Defibration of the prehydrolyzed sawdust results in still shorter cooking times. Decrease in cooking time goes parallel with a decrease in yield.

Table IV gives the conditions of bleaching and data for the bleached pulps. All pulps show analytical data accepted for rayon pulps. The filterability, determined by an industrial method,* was between 520 and 645 ml. per sq. cm. as compared with 450 to 700 for industrial rayon pulps, determined by the same method. The yields from sawdust, calculated on original material, are remarkably lower than the yields from chips, the reason being loss of fines, originating from damaged fibers. When the suspensions of bleached or unbleached pulps from sawdust coming from the 100-mesh screen were filtered through paper, fines amounting to 90% of the differences in yield between chips and sawdust were recovered. The D.P. of the fines was remarkably lower than the D.P. of the pulps.

Spinning of Viscoses

Besides the filterability of viscose its spinnability is important. One of the characteristics which determine spinnability is the chain-length distribution.

The pulps were treated in slurry with 20 parts of 18.5% NaOH for 90 min at 15°C., pressed to a factor of 3.0, shredded for 2 hr. at 22 to 26°C., and aged 30 hr. at 20°C. Xanthation with 36% CS_2 followed. The viscoses (Table V) were spun in a Mueller bath with a takeoff of 55 m. on the first bobbin and the filaments further stretched to maximum stretch. After washing, the rayon was conditioned at 20°C. and 50% R.H. for testing.

Table V indicates that there is practically no difference in spinning and filament qualities between pulps from chips and defibered sawdust, whereas the quality of the pulp from non-defibered sawdust is clearly inferior. Under the comparable conditions chosen, it is impossible to achieve the same stretch without filament breakage, as also indicated by the denier values. Tenacity and elongation are unsatisfactory.

In order to establish whether the reason for improvement of the pulps from defibered sawdust is the greater uniformity of the degree of polymerization pulps P-1 and P-2 were fractionated (*2*) and the results, as shown in Fig. 5, are in accordance with expectation.

SUMMARY

The application of the conventional process of acid prehydrolysis, sulfate pulping and three-step chlorine–hypochlorite bleaching on sawdust from loblolly pine and gum leads to viscose-grade pulps comparable with commercial grades. The yield, calculated on sawdust used, is in both cases considerably lower than the yield from corresponding chips.

If after the acid prehydrolysis the sawdust is defibered and screened, the quality of the pulp is considerably improved. The reason for this improvement is a greater uniformity in the degree of polymerization of the pulp. The yield is decreased by this treatment still further.

LITERATURE CITED

1. Lauer, K. and Chao-Wu, H., *J. Alabama Acad. Sc.* 31(1959)
2. Heuser, E. and Joergensen, L., *Tappi* 34, 57 (1951).

* The author is not free to publish details of this filterability method which is the property of a rayon manufacturer.

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Effects of Various Percentages of Monosulphite Straw Pulp for Packing Papers

G. BOTTO MICCA and E. GRANDIS

It is possible to manufacture kraft bag paper of good quality with a furnish containing, beside kraft pulp, unbleached monosulphite wheat-straw pulp up to a maximum of 20%. The paper produced shows better strength characteristics, both static and dynamic, except tear strength which is lower. The beating of the furnish containing straw pulp requires a lower power consumption than the furnish containing kraft pulp alone. The two different types of furnishes have the same behavior when running on a modern kraft paper machine. The addition of straw pulp also improves the quality of gumming paper and of asphalting paper.

Cartiere Burgo began to take an interest in the production of straw pulp as early as 30 years ago in cooperation with Cartiera di San Giovanni Lupatoto. Later, a small plant for the production of straw pulp was installed at our Romagnano Sesia mill. For many years this plant produced both wheat and rice straw pulp, these raw materials being abundant in that region.

But it was only ten years ago that a mill specially designed for this kind of production was installed at Ferrara with a yearly output of 15,000 tons of monosulfite straw pulp. This mill has a set of rotary digesters for direct steam cooking and a Kamyr continuous digester. Only high class wheat straw pulp is being used, coming from the Ferrara region. Unbleached, half-bleached and bleached pulps are being produced, and we can also manufacture these different qualities simultaneously.

We generally use straw pulp in many grades of paper, such as printing papers which require a well-closed formation, remarkably high picking resistance, absence of fuzz, and a good sizing. In the field of wrapping papers straw pulp can be advantageously used in highly beaten papers, namely, in greaseproof and glassine papers of standard and cheap lines. The easy hydration, transparency of the sheet, and good drainage on the wire put straw-pulp in the first place, when considering in particular its rather low price, the beating savings, and good results obtained.

A development which we have been using for many years is represented by the use of small percentages (up to a maximum of 20%) of straw pulp in the production of bag kraft paper and other similar papers. This allows a definite improvement to be obtained both in manufacturing conditions and in the quality of paper produced. It can even be said that in such a case straw pulp acts as an actual manufacturing additive, rather than as a pulp. Such an addition can originate a certain perplexity from a strictly commercial point of view, as pulps different from unbleached sulfate pulp are usually found only in cheap quality wrapping papers; whereas, in our case, the problem is to produce a bag kraft paper which may be quite regular and as suitable as the one made of kraft pulp alone.

Our investigations were divided into two parts: (1) the study of strength characteristics and other properties of kraft pulps containing 10 and 20% straw pulp; and (2) mill manufacture of the straw-kraft papers.

LITERATURE SURVEY

The various authors who have studied recently the properties of the papers containing a blend of both softwood and short-fibered pulps, have proved that the addition of a limited quantity of short-fibered pulp to softwood pulps does not af-

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fect the strength properties of the latter but can even improve them.

As regards hardwood pulps, we would quote, for all, the studies of Jensen and his school (*1*), from which it clearly appears that if 10% of birch sulfate pulp is added to pine sulfate pulp, a slight improvement of the strength properties can be obtained, while the mixture containing 20% of birch pulp has the same properties as pine sulfate pulp alone. If, on the contrary, sulfite pulp is used (*2*), it can be observed that the addition of 10% of birch sulfite pulp does not affect the strength properties adversely, with the exception of the folding endurance which decreases slightly. On the other hand, it is well known that some brands of Swedish sulfate pulp which have higher strength characteristics contain up to 10% of birch pulp.

As to straw pulp, Boesen and Flindt Kruse (*3*) have found that bleached straw pulp can be used in considerable percentages associated with bleached softwood sulfite pulp for the manufacture of various grades of writing and printing paper. In all cases an increase of the strength properties has been ascertained, with the exception of the tear resistance.

Brecht and his school (*4, 5*) have conducted extensive research both in the laboratory and in the mill on the properties of paper containing bleached sulfite spruce pulp and bleached sulfate straw pulp. While laboratory results showed that the addition of straw pulp decreased the paper strength, research carried out at the mill showed that paper containing high percentages of straw pulp is more resistant than one containing only softwood pulps (with the exception of a slight reduction in the tear resistance). Brecht explains this difference in behavior by the different beating conditions of straw pulp, which in the mill run was processed very mildly so as to develop the maximum strength.

Van Nederveen and Hellenberg (*6*) studying the beating behavior of blends of bleached straw pulp and bleached sulfite softwood pulps found that better results can be obtained by beating together the pulps of the furnish, instead of mixing the pulps which had been beaten separately.

Aronovsky and co-authors (*7*), using the laboratory fourdrinier machine of the Forest Products Laboratory, Peoria, Ill., made various types of paper containing straw pulp beaten to a Canadian Standard freeness of about 190 ml. (50°S.-R.). The types of paper made were: newsprint, magazine paper, magazine coating base paper, waxing paper, bond paper, and greaseproof paper; all these grades being made with various percentages of bleached straw pulp, and bag paper with unbleached straw pulp. In all cases these authors observed an increase in strength characteristics (with the exception of tear resistance); in particular the addition of 25% of unbleached straw pulp beaten to a freeness of about 180 ml. (approx. 55°S.-R.) to unbleached kraft pulp beaten to 600 ml. C.S.f. (20°S.-R.) caused an increase of 25% in the bursting strength and of 20% in the tensile strength while the tearing resistance decreased only 13%. A considerable increase was also observed both in the formation and surface texture of the paper.

When analyzing the results obtained by these authors, we notice that some have found that straw pulp produces a more-or-less considerable increase of the strength properties, whereas other authors observed a slight decrease.

We think that such discrepancies are to be ascribed to the different qualities of straw pulps employed and to the beating conditions which were applied. All authors agree, however, that through the use of straw pulp a considerable reduction in beating time can be obtained, with a resulting better formation and finish of the paper.

From this point of view the effect of a certain percentage of short-fibered pulps (provided they are properly beaten) can be considered as roughly equivalent to the effects which are obtained through a cutting action on a fraction of the fibers of softwood, and it allows the same improvement to develop both in the formation and evenness of the sheet structure.

STUDY OF STRENGTH CHARACTERISTICS OF KRAFT PULPS CONTAINING STRAW PULP

This study has been carried out on furnishes of pure kraft pulp, to which 10 and 20% of unbleached monosulfite straw pulp were added; the furnishes were beaten in a laboratory beater. In part of these runs the pulps were mixed and then beaten, while in the other ones, the pulps of the furnish were beaten separately and then mixed. The sheets were made with a laboratory sheet machine and both conventional and dynamic strength characteristics were determined on them.

Experimental

The pulps employed were as follows: unbleached sulfate pine pulp, produced by our Cuneo mill, with about 60% moisture; unbleached monosulfite wheat-straw pulp produced by our Ferrara mill, with about 70% moisture.

These pulps were disintegrated at a consistency of 4% in a disintegrator similar to the one described in TAPPI Standard Method T 200 m 45 (2 and 1 min. for kraft and straw pulp, respectively), and they were then processed at a consistency of about 2% in a Niagara-type beater. After making the beater run unloaded for 5 min., a variable weight was applied, according to the beating conditions which had been chosen. Both the beating degree and draining time were then determined on the furnish. The draining time is that required to empty the Sandberg-Bergman sheet machine, filled with a fixed quantity of water.

The sheets, basis weight of 70 g. per. sq. m., were made with a Sandberg-Bergman sheet machine, then pressed in a Wennberg press and dried in a Wennberg drum drier, modified and supplied with a wire, at a temperature of 90°C., for 5 min. The shrinkage undergone by the sheets is equal to that undergone with free air-drying. The sheet tests were carried out in a conditioned room at a temperature of 20°C. and 65% R.H.

The following tests were carried out on the handsheets: Usual strength tests, namely, density, stretch, breaking length, burst factor, and tear factor. All these tests being reported as in TAPPI Standard Method T 220 m 53; the folding endurance was measured with an MIT apparatus.

Tests of breaking energy: breaking energy was calculated according to the formula:

$$RC = K \times A \times P$$

RC = calculated breaking energy, cm.-kg.
P = breaking load, Kg, determined on a Schopper type tensile rester.
A = stretch, cm. (on strips 18 cm long), determined on a Schopper type tensile tester
K = constant (0.62 − MD; 0.72 − CD)

stated in the Merkblatt 11 of the Gemeinschaft Papiersackindustrie und Vereinigung Natronpapiere. However, because of the isotropic structure of the sheets we had prepared, the two constants, 0.62 and 0.72, indicated for both the machine- and cross-direction of the paper were replaced by their mean value, 0.67; the breaking energy was determined with the Bekk dynamometer, while the absolute bursting energy was obtained with a Frag tester.

Other strength tests were performed as mentioned previously, but were determined on specimens previously dried in an oven for 3 hr. at 105°C., as described in the work of Burgstaller and Krauss (*8*). A part of the tests were carried out on specimens that had just been removed from the oven, whereas other tests were carried out on specimens dried and then conditioned for 18 hr.

Porosity was determined with the Gurley apparatus (time in seconds for the flow of 100 ml. of air).

Description of the Tests

The following series of runs were carried out:

A. Preparation of furnishes containing kraft pulp beaten at three different beating degrees with additions of 0, 10, and 20% of straw pulp beaten at three different beating degrees.

Table I. Meaning of the Symbols Used in the Figures

Tests on the paper undried, conditioned	*Tests on paper oven-dried at 105°C., 3 hr.—specimens just taken out of the oven*	*Test on paper oven-dried at 105°C.—specimens conditioned for 18 hr.*
SR = beating degree.	As = stretch, %.	Asc = stretch, %.
SC = draining time, sec.	Ls = breaking length, m.	Lsc = breaking length, m.
D = density, g./cc.	RCs = calculated breaking energy, cm.-kg.	RCsc = calculated breaking energy, cm.-kg.
A = stretch, %.	RBs = Bekk breaking energy, cm.-kg.	RBsc = Bekk breaking energy, cm.-kg.
L = breaking length, m.	F.T.s = absolute burst energy, kgm. 10^{-4}.	F.T.sc = absolute burst energy, kgm. 10^{-4}.
RC = calculated breaking energy, cm-kg	Ss = burst factor.	
RB = Bekk breaking energy, cm.-kg.	Es = tear factor.	
F.T. = absolute burst energy, kgm. 10^{-4}.	Ps = folding endurance MIT, no. double folds.	
S = burst factor.		
E = tear factor.		
P = folding endurance MIT, no. double folds.		
Po = Gurley porosity, sec.		

The two pulps were beaten separately in a beater of the Niagara type, with a load of 6 kg.

B. As for test (A) but with straw pulp refined in a Niagara-type beater, with a load of 1.5 kg.

C. Preparation of a blend of kraft pulp with additions of 0, 10, and 20% of straw pulp, and beating up to a pre-established beating degree in a Niagara beater, with a load of 6 kg.

D. Preparation of a blend of kraft pulp with additions of 0, 10, and 20% of straw pulp, and beating for a given beating time in a Niagara beater, with a load of 6 kg.

As the differences in the properties of paper obtained from the different experiments were relatively small in comparison with the variability of the results pertaining to such tests, two or three quite similar experiments were carried out per point.

RESULTS

Characteristics of the Pulps Employed

Figure 1 shows the properties of the pulps used for these experiments. The curves have been drawn from the average data of all the runs carried out on the pulps in a Niagara beater, with a load of 6 kg. This figure comprises 25 graphs, one for each of the characteristics listed previously. The legend for the ordinate symbols is given in Table I, while the three scales at the abscissae are time, which is common to both the pulps, and two scales for S.-R.°, which are different for the two pulps.

Straw pulp is beaten far more quickly than kraft pulp. In 50 min. straw pulp goes, from 36°S.-R. (which is the beating degree of the disintegrated pulp) to 70°S.-R.; at the same time kraft pulp increases only from 13 to 27°S.-R.

Both apparent density and stretch are greater in straw pulp; while breaking length, calculated breaking energy, Bekk breaking energy, absolute burst energy, and burst factor are far lower in straw pulp, with the exception of the first minutes of beating, when kraft pulp is still extremely free while straw pulp is already rather wet. Finally the tearing resistance of straw pulp is only a fraction of that of the kraft pulp.

In the tests carried out on oven-dried specimens, it can be observed that in comparison with the conventional ones, the breaking length increases while stretch, burst factor, tear factor, folding endurance, and Bekk breaking energy decrease. It must also be noticed that the Bekk breaking energy decreases considerably while, on the contrary, the calculated breaking energy and absolute burst energy maintain values of the same magnitude as the normal ones. All the curves of the tests on specimens previously oven-dried are flatter than the others, but the position of the curves for the straw pulp in comparison with the kraft pulp is nearly the same in both sets of tests. Only the dry stretch of straw pulp is far lower than that for kraft pulp, the conventional one being, on the contrary, greater. Finally, the tests on the specimens oven-dried and then conditioned for 18 hr. show that both kraft and straw pulp have acquired the original properties they had before the treatment, with a probable overall increase in regard to the latter. This also applies to the Bekk breaking energy, which had shown a considerable decrease in the specimens examined after drying.

Furnishes from Pulps Beaten Separately

In test series (A) kraft pulp was beaten at 18, 25, and 32°S.-R., in a beater with a load of 6 kg., while straw pulp was beaten at 36 (disintegrated), 50 and 70°S.-R., in a beater also with a load of 6 kg.

The three straw-pulp runs were mixed with the three kraft-pulp ones, with a percentage of 10 and 20%, respectively.

Series (B) was obtained in the same manner as the previous one, but the straw pulp was beaten in the beater with a load of 1.5 kg.

In planning both these experiments it was thought that the different straw pulp beating conditions would lead to different results, namely, that the more mildly beaten straw pulp would present strength characteristics higher than that for the pulp beaten in a more drastic way. On the contrary, it could be observed that the only important difference between both these beatings lies in the beating time, other characteristics not differing appreciably.

For this reason, in the evaluation of these furnishes we preferred to take as a basis the overall data corresponding to the average of the ones resulting from the two experiments.

In order to outline properly the influence of the addition of straw pulp on the properties of either the furnish or paper we will refer our considerations to the variations in the values of the characteristics that could be obtained from the runs containing straw pulp in comparison with corresponding runs containing only kraft pulp. In Fig. 2 (25 graphs, arranged as for Fig. 1) the beating degree of the straw pulp used for the blend is given on the abscissae and the ordinates give the values of the variations in the characteristics of the various furnishes containing straw pulp in comparison with those of pure kraft pulp.

Each graph is divided into three superimposed sections, corresponding to the three runs of kraft pulp. In each section the zero of the ordinate scale (0) corresponds to the representative point of the furnish composed of kraft pulp only. The position of this point in relation to the abscissae is arbitrary, as the scale of the latter corresponds to the Schopper-Riegler freeness of the straw pulp; hence, O has been joined to the beginning of the curves with a dotted line. This is to be considered only as a reference line and is designed to indicate the difference in level between the curves and points to which they are connected. Each section includes two curves corresponding to 10 and 20% straw pulp, respectively.

Of course, there is an increase in both beating and draining degrees, and in the density of mixed furnishes: such characteristics, which are already higher in straw pulp than in kraft pulp, increase as the beating degree of straw pulp and the percentage used increases. Similarly, stretch, breaking length, and characteristics of the dynamic resistance increase in all mixed furnishes even if, as already pointed out, both breaking length and dynamic characteristics of the straw pulp are far lower than those of the kraft pulp.

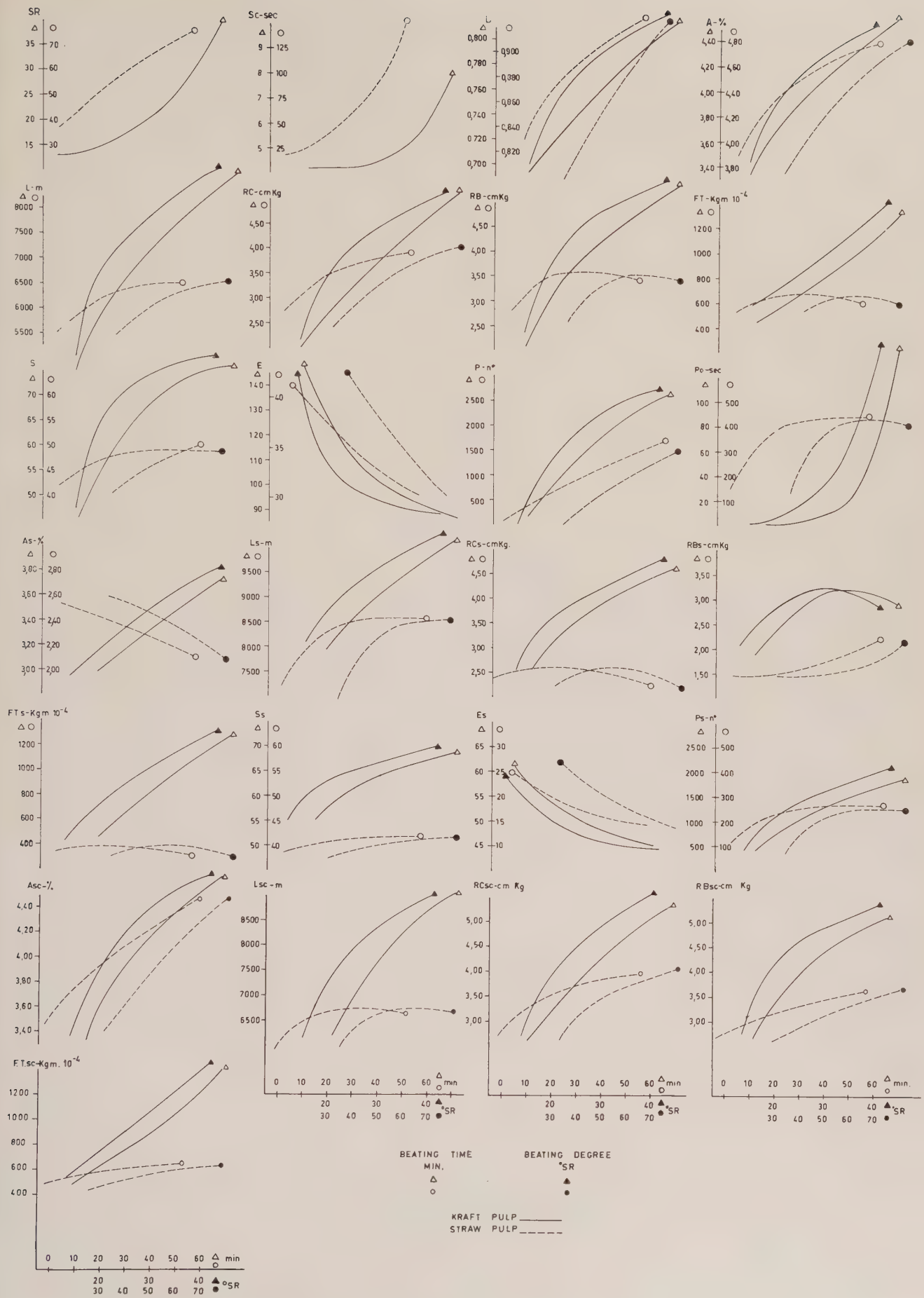

Fig. 1. Properties of pulps used for the experiments

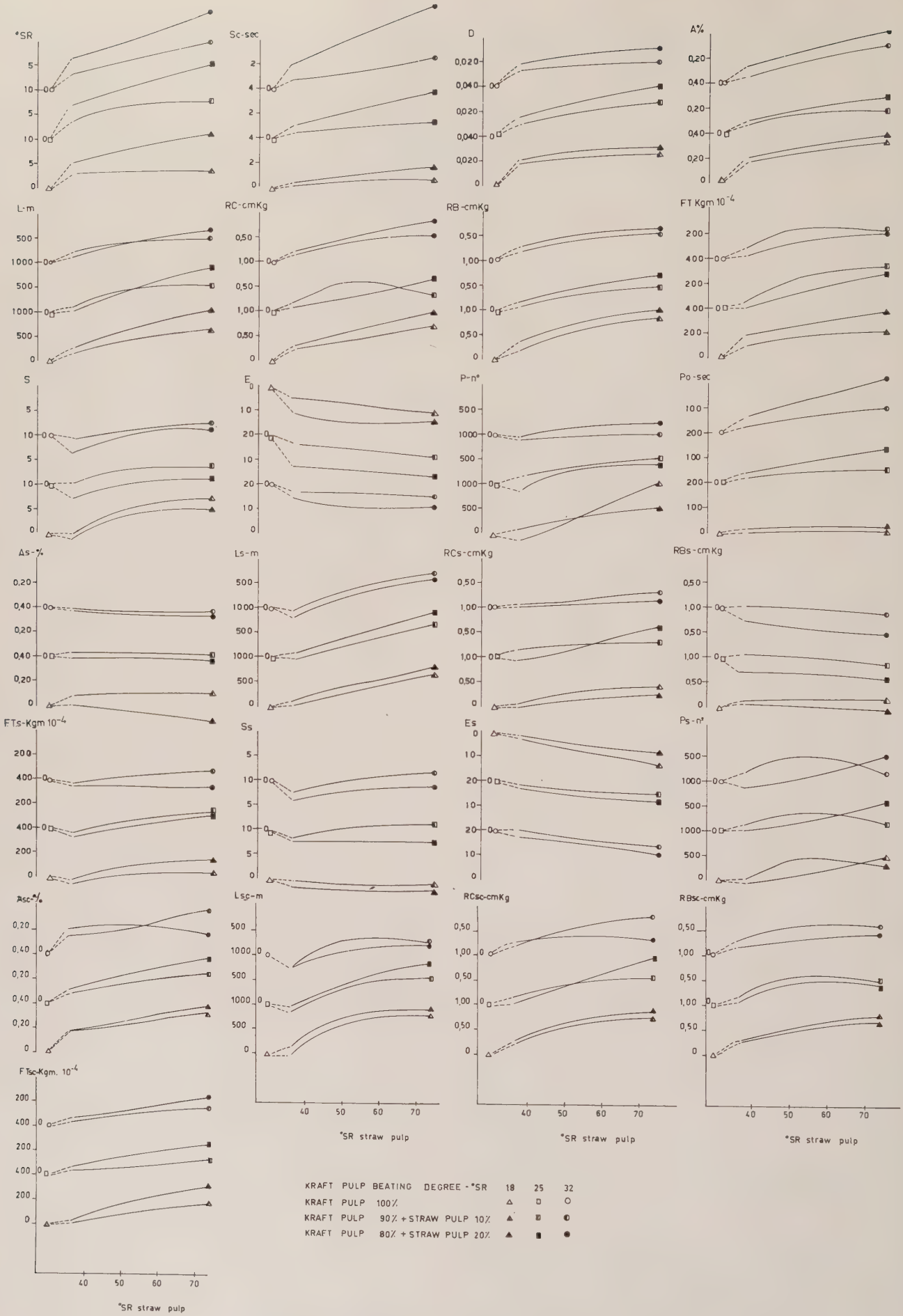

Fig. 2. Properties of furnishes and sheets obtained from pulps beaten separately

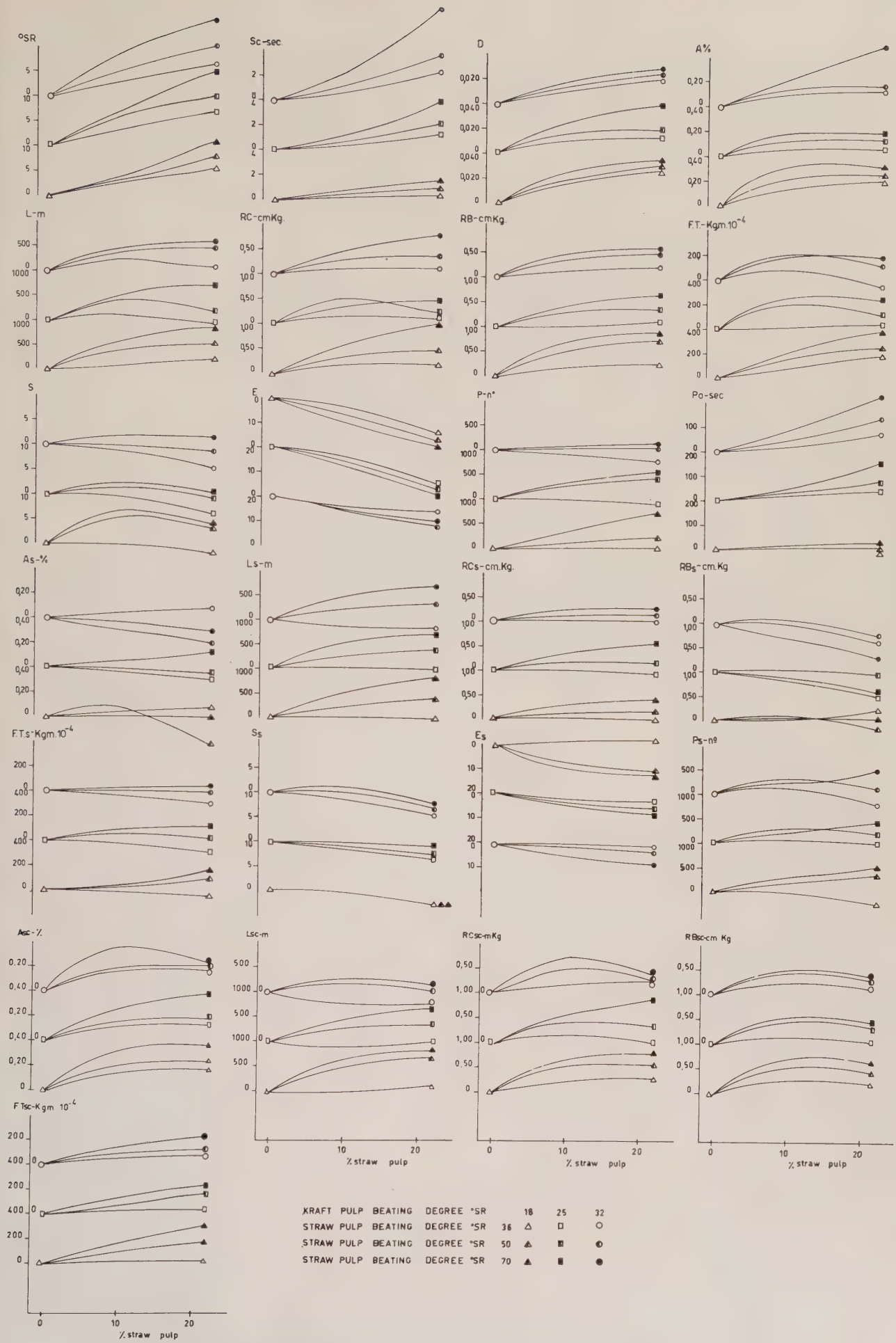

Fig. 3. Properties of furnishes and sheets obtained from pulps beaten separately

In general, this increase is sharper when the basis furnish is formed of pulp at 18° S.-R., this being also the case when the difference between the strength of both straw pulp and kraft pulp is smaller. In other cases, when such a difference is considerably greater, the strength increase of the paper containing straw is lower but is always well defined. The burst-strength behavior, on the contrary, is slightly different, as it decreases because of the addition of straw pulp at 36° S.-R. But if the beating degree of the straw pulp increases, so does the paper strength, more rapidly in the case of kraft pulp at 18° S.-R., and slower in the other cases. In the blends containing highly beaten straw pulp, the burst factor of the blend is always higher than that of the kraft pulp alone. A likeness can immediately be noticed in the forms of the burst-factor and absolute burst-energy curves, particularly since in the two upper sections of both the curves, the one corresponding to 10% straw pulp runs above the 20% one. However, the curves of the absolute burst energy show, with the exception of one single point, an accentuated trend to increase, a trend of the same extent as the one relating the other dynamic characteristics. The tearing resistance of the blends is always definitely lower than that of the kraft pulp alone, which was to be expected, owing to the great difference existing between the two pulps in this particular connection. The folding endurance has an irregular behavior and has not a definite value. The porosity greatly increases as well as the beating degree.

The tests carried out on the oven-dried show a less regular trend than others. The only characteristic showing as large an increase as in the conventional tests is the breaking length; all other tests, on the contrary, show lower increases as far as calculated breaking energy, absolute burst energy, and folding endurance are concerned, or they can also decrease slightly, such as the Bekk breaking energy and burst factor.

It must also be observed that the decrease undergone by the tearing factor is less than in the conventional tests. In such extreme conditions, however, which are not accompanied in practice, the behavior of the paper containing straw pulp is, on the whole, more favorable than that of pure kraft pulp.

If, finally, we consider the tests on oven dried specimens and then conditioned for 18 hr., we can notice that the stretch, as well as the calculated breaking energy, Bekk breaking energy and absolute burst energy show values similar to the ones of the tests on the undried specimens, while the trend of the curves representing the breaking length is nearer to that of the curves drawn from the specimens examined soon after the drying has been completed.

The comparison between the different graphs representing the Bekk breaking energy is of particular interest: Whereas a considerable increase can be noticed with the undried specimens and with those conditioned after drying; a remarkable strength decrease can be observed. On the contrary, soon after they are removed from the oven.

Figure 3 shows the same data versus the straw pulp percentage of furnishes. In this figure each section is composed of three curves, corresponding to the three straw pulp runs at 36, 50 and 70° S.-R. This type of diagram shows, in particular, the cases in which a maximum paper strength is obtained with 10% of straw pulp.

An examination of Figs. 2 and 3 leads to the conclusion that the most satisfactory results can be obtained through the use of beaten straw pulp at 50° S.-R. In fact, the strength increase obtained by increasing the pulp beating degree beyond this limit is somewhat poor. As regards the percentage of straw pulp to be used, the optimum is between 10 and 20%. In some cases in fact a decrease can be noticed by passing from the lowest percentage to the highest one, and there is reason to believe that these falls should increase with higher percentages.

The addition of straw pulp always causes an increase in the beating degree. When comparing the behavior of the kraft pulp alone with that of the blends containing straw pulp (Figs. 1 and 2), it can be found that furnishes with a nearly equal beating degree correspond to equal values of the strength properties; in general, however, to obtain balance, it is necessary that the blends have a beating degree a few points higher than for the kraft pulp alone.

It is interesting to compare the changes actually obtained through the addition of straw pulp with those resulting from the calculation, by applying the rule of mixing, to the different furnishes. In Fig. 4 some of the more important graphs of Figure 2 have been reproduced, and values calculated by the foregoing rule are given by the dotted lines. With the exception of the 10% blend of straw pulp at 70°S.-R. with kraft pulp at 18°S.-R., the calculated beating degree is always lower than the actual one. As to the

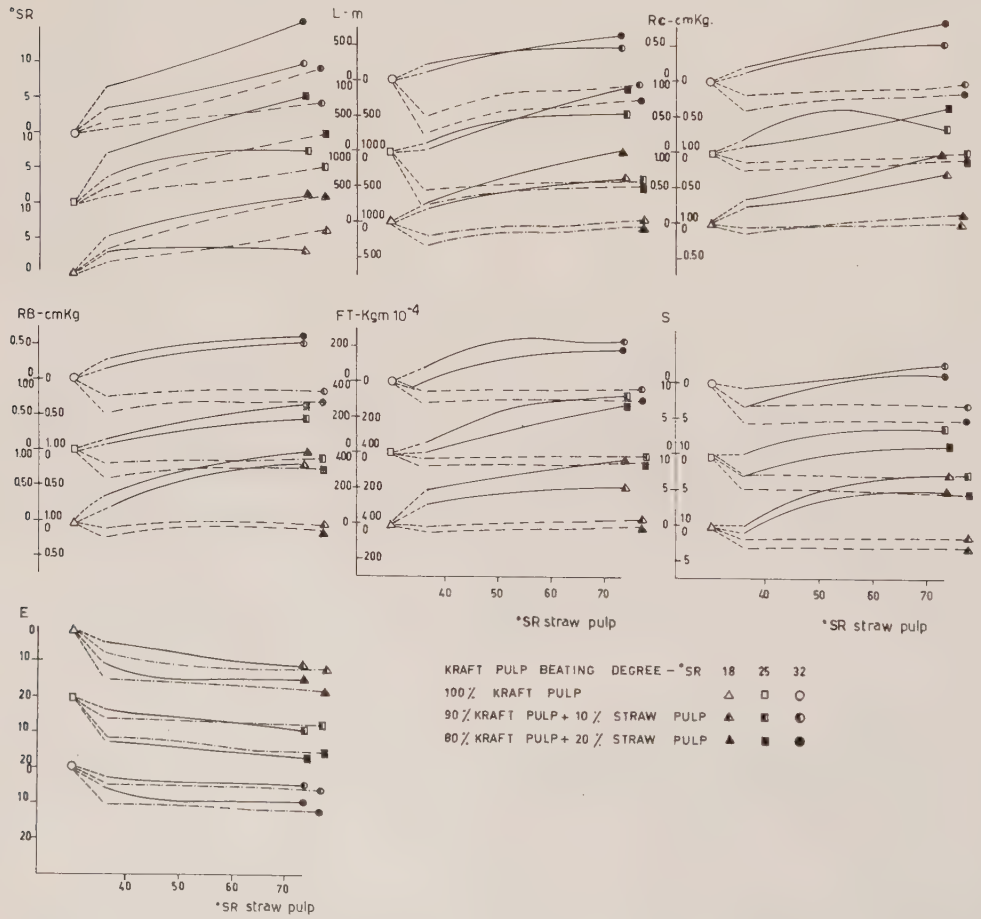
°SR
L - m
Rc - cmKg.
RB - cmKg
FT - Kgm 10⁻⁴
S
E
°SR straw pulp
°SR straw pulp
°SR straw pulp
KRAFT PULP BEATING DEGREE - °SR 18 25 32
100 % KRAFT PULP
90 % KRAFT PULP + 10 % STRAW PULP
80 % KRAFT PULP + 20 % STRAW PULP

Fig. 4. Properties of furnishes and sheets obtained from pulps beaten separately

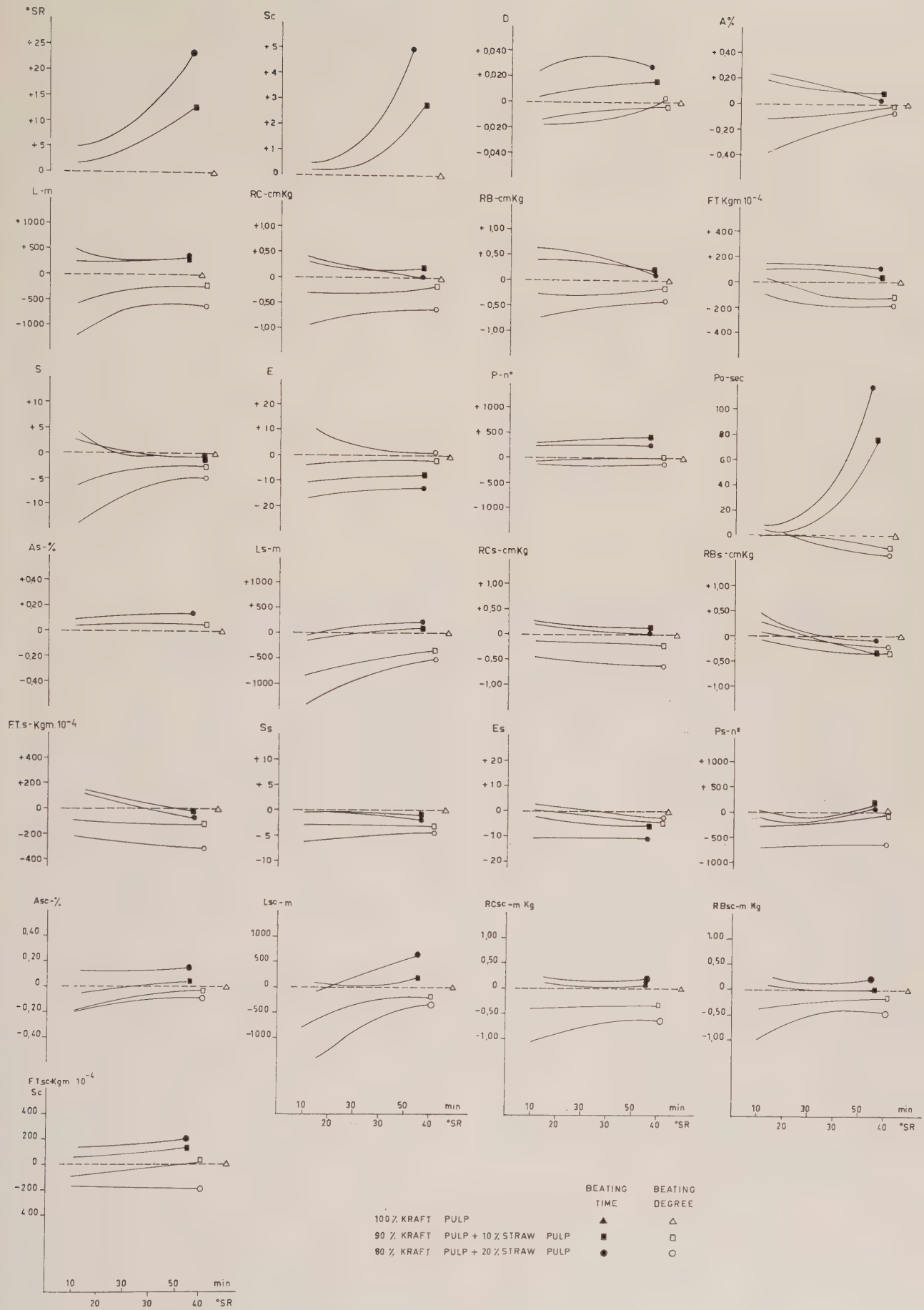

Fig. 5. Properties of furnishes and sheets obtained from pulps beaten together

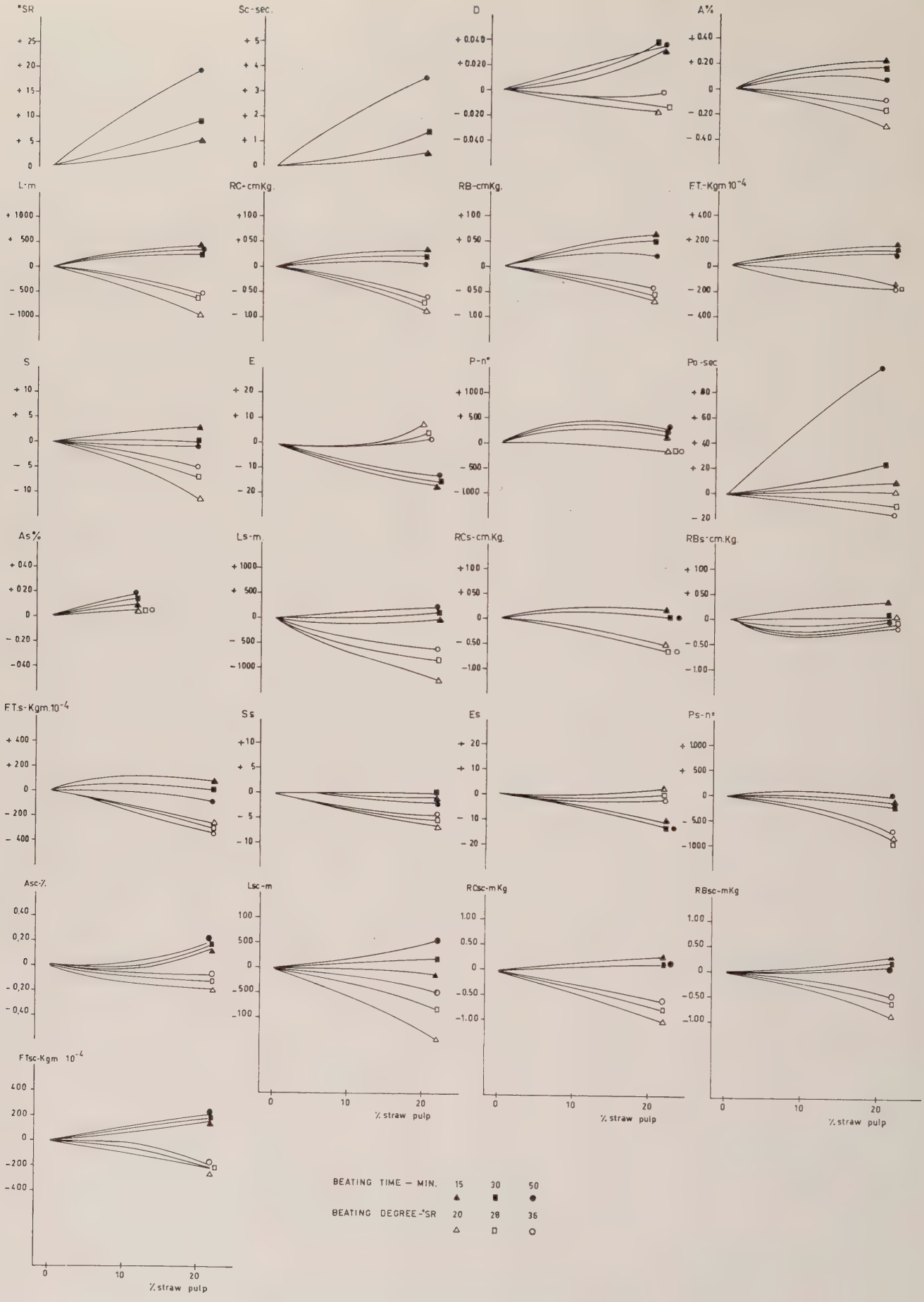

Fig. 6. Properties of furnishes and sheets obtained from pulps beaten together

strength properties, the values calculated for the blends are always lower than those for the kraft pulp alone even when, as in most cases, the experimental value shows a considerable increase. This proves that the strength increase observed is due to some interaction between softwood pulp and straw pulp, which allows the latter to emphasize the properties of the former.

The power consumptions are always in favor of straw pulp. When referring to the beating times, which is the only system we can use in laboratory, as well as to the graph showing the beating degree in Fig. 1, we find that the beating times of straw pulp at 70°S.-R. correspond to those of the kraft pulp at 24°S.R., and the beating times of kraft pulp at 18°S.-R. to those of the straw pulp at 61°S.-R. It follows, therefore, that nearly all the blends we have tested require overall beating times lower than for kraft pulp.

Furnishes of Pulps Beaten Together

In test series C, three sets of furnishes were prepared: 100% kraft pulp; 90% kraft pulp plus 10% straw pulp; and 80% kraft pulp plus 20% straw pulp. Each of these furnishes was beaten at 20, 30, and 40°S.-R., respectively, in a Niagara beater with a load of 6 kg.

In test series D, furnishes of similar composition were used but beating was carried out with reference to time, five time intervals per furnish.

In this case also the evaluation was made on the entire data of the two sets of tests, and with a system similar to the one described previously. Fig. 5 was thus obtained. The abscissae of these graphs have two scales: time and degree of freeness. At the ordinates both increases and decreases are shown as they were obtained from the characteristics of the various furnishes containing straw pulp in comparison with those of kraft pulp beaten for the same period of time or at the same degree of freeness. Two curves are missing in the *As* graph because the points representing them were not reliable.

In all cases, with the exception of the tearing resistance, it can be observed that beating time being equal the blend characteristics are higher than the ones for kraft pulp alone. The highest increase occurs at the beginning of the beating process and it tends to decrease as beating goes on. In general, the blends having 20% straw pulp show greater strength than those having 10% of the pulp, the difference, however, being small. For the same beating degree the comparison shows the blend characteristics to be always lower than for the kraft pulp.

As stated previously, for the blends obtained from pulps beaten separately, the beating degree with kraft pulp alone being equal, the strength difference is very small; in this case, on the contrary, the difference is more remarkable. Such a difference is far greater for the lowest beating times, and it depends on the fact that in this stage of beating the increase in the beating degree is mainly due to the straw pulp hydration. Assuming that during the beating process the two fibrous materials should behave as if they were separated (on approximate assumption since we are unable to prove it), by comparing Figs. 1 and 5 we can conclude that the 20% blend of straw pulp, which reaches 27°S.-R. in 30 min., actually contains kraft pulp at 18°S.-R., and straw pulp at 61°S.-R.

Clearly it appears that such a blend cannot have the same strength as a kraft pulp, which, alone, has reached 27°S.-R., taking, however, 50 min. But the 20% blend of straw pulp, after 50 min. beating has far better properties than the ones of the kraft pulp alone.

Figure 6 shows the same data of Fig. 5 but versus the contents of straw pulp. When comparing this figure with Fig. 3, it can be noticed that, in general, the observations already made for separate runs also apply to these graphs as the curves show the same trend; however, the strength improvements which can be attained by beating the pulps together are lower than those obtainable by mixing the pulps beaten separately.

As a first approximation, the power consumptions considered as the necessary times to attain an equal strength of kraft pulp in comparison with the blends containing straw pulp are decidedly in favor of the latter, just on account of the fact that, the time being equal, the properties of the blends are better than those of kraft pulp.

EXPERIMENTS ON CONTINUOUS BEATING OF FURNISHES CONTAINING STRAW PULP

Those who are well acquainted with paper mills and have spent much time near paper machines know well how difficult it is to conduct systematic runs on the continuous machine and to draw from them reliable information when the changes which have been made are not of a remarkable importance. The unavoidable variations of all the factors contributing to the maintenance of the balance minimize the difference, and it even happens sometimes that these variations may lead to contradictory results. Only a long series of observations, made on a same type of paper and in machine working conditions being as much as possible equal, may lead to definite conclusions. For these reasons we prefer to state the results of a refining test we were able to carry out on a 2-m. wide fourdrinier machine, which, for many years, made various qualities of wrapping papers by using a set of hollanders for beating. These beaters have been superseded lately by a disk refiner, and it has just during the setting up of such a plant that three beating runs were carried out, namely:

(a) With a blend of 85% kraft pulp and 15% straw pulp, beaten separately;

(b) With a blend having the same composition as (a) but by refining all pulps together in the same furnish.

(c) With kraft pulp alone.

For run (a) the kraft pulp was disintegrated in a hydrapulper and was then circulated from a box through a disk refiner which absorbed the maximum allowed load of 230 amp (at 500 v.). The operation was continued until the pulp had reached 26°S.-R. The monosulfite straw pulp (15% on the total quantity) was beaten mildly at about 48°S.-R. The blending of the two pulps beaten separately was carried out in a machine chest; the furnish had a beating degree of 35°S.-R. Finally, 0.2% of rosin size and 0.5% of alum were added.

For run (b) both the pulps (85% of kraft pulp and 15% of straw pulp) were pulped together in a hydrapulper and delivered to a machine chest. Hence the stuff passed continuously through the disk refiner and reached directly the headbox. The working conditions of the disk refiner were as follows: absorbed load, 235 amp.; entrance pressure of the stuff in the disk refiner, 1.8 kg. per sq. cm.; beating degree of the stuff, 32°S.-R.

In run (c) we acted as in (b), but with a furnish composed only of kraft pulp. With a power consumption of 245 amp., which was, therefore, slightly higher than for run (b), the beating degree of the pulp was of 21°S.-R., with a difference of 11°S.-R. in comparison with the furnish of the previous run containing straw pulp.

Papers were evaluated for the same characteristics described in the first part of this report. The results for evaluation of the papers are presented in Table II; for hand-sheets prepared from the different furnishes in Table III.

As expected, the data for the three mill runs confirm the findings of the laboratory experiments, that is, the blend of pulps beaten separately provides data which are slightly better than the blend beaten altogether, whereas the paper made only of kraft pulp is decidedly worse. Also the experiments on furnishes provide the same confirmation.

We wish to point out first of all that the beating system had not been designed for treatment of furnishes composed of kraft pulp alone. This explains the low beating degree obtained in run (c).

Table II. Properties of Paper Obtained from Mill Runs

	Units	Paper undried, conditioned Run (a)	Run (b)	Run (c)	Paper dried at 105°C. and then conditioned Run (a)	Run (b)	Run (c)
Weight	g. per. sq. m.	64	62	62	..	..	..
Density g./cc.	g. per. sq. m.	0.640	0.623	0.583	...	..	..
Stretch							
MD	%	2.08	1.85	1.84	1.97	2.07	2.07
CD	%	5.03	5.07	4.32	4.02	4.92	4.48
Av.	%	3.55	3.46	3.08	3.00	3.49	3.27
Breaking length							
MD	m	6660	7100	6100	7340	7770	6650
CD	m	3620	3520	3160	4000	3510	3250
Av.	m	5140	5310	4630	5670	5640	4950
Calcd. breaking energy							
MD	cm.-kg.	1.54	1.36	1.20	1.59	1.58	1.47
CD	cm.-kg.	2.35	2.12	1.69	2.01	2.05	1.80
Av.	cm.-kg.	1.95	1.74	1.44	1.80	1.82	1.64
Bekk breaking energy							
MD	cm.-kg.	1.85	1.73	1.64	1.89	1.76	1.64
CD	cm.-kg.	2.79	2.44	1.92	2.64	2.16	1.85
Av.	cm.-kg.	2.32	2.08	1.78	2.27	1.96	1.75
Absolute burst energy							
MD	kgm. 10^{-4}	374	378	312	410	367	345
CD	kgm. 10^{-4}	517	454	364	555	483	410
Av.	kgm. 10^{-4}	440	416	338	483	425	377
Burst factor		46.3	46.2	43.9			
Tear factor							
MD		105	99	131			
CD		118	112	142			
Av.		111	106	136			
Folding endurance							
MD	No.	1400	1050	1100			
CD	No.	950	420	540			
Av.	No.	1170	740	820			
Gurley porosity	sec.	26	26	6			

The paper produced during these experimental runs had less strength than papers normally produced on this machine; in fact, the machine had not been designed to produce such a grade and the shortness of the run did not allow us to set it up. On the other hand, the purpose of these experiments was not to make bag paper, but to compare the behavior of the furnishes, the applied conditions being equal.

REMARKS ON THE INDUSTRIAL PRODUCTION OF KRAFT PAPER CONTAINING STRAW PULP

Kraft Bag Paper

We usually manufacture this grade of paper on a modern fourdrinier machine at the speed of 250 to 280 m. per min. with a daily output of 70 to 80 m. tons. The reasons which lead us to use small percentages of straw pulp as an additive for the kraft furnish ensue logically from the results shown in the first part of this study. Though we are convinced that the addition of straw pulp beaten separately allows us to obtain slightly better results, it is our practice for the sake of simplicity (as we have a continuous beating system) to beat the pulp blends direct.

The subject of beating behavior was discussed when the mill runs were considered. We now add that the presence of straw pulp in small quantities considerably improves sheet formation on the wire. Furthermore, its presence does not alter the drainage of the stuff and even stabilizes it.

As regards the ease of water removal at the presses, no substantial differences can be noticed in relation to a kraft furnish only, and the same can be stated with regard to the drying rate.

A lower quantity of dust can be noticed on the calender and in the tuber during the bag manufacturing process. In this connection, it was objected that also small percentages of straw pulp considerably reduce the paper porosity. This is true, as can be seen from the results of our tests; it is well known, however, that at present such a requisite is not needed any longer, as it is easier to carry out the perforation of the paper in the tuber.

Finally, the following remarks must be added: in long-fibered paper such as kraft and wrapping paper in general, it is also necessary to proceed with a cutting action besides the hydration, though within moderate limits. This helps not only to improve the sheet formation but mainly to close better the sheet texture.

If only disk refiners are being used, it will not be possible to obtain the desired cutting action, whereas the addition of straw pulp completely fills this gap. On the other hand, many people rightly state that it is not logical to cut long fibers

Table III. Properties of Pulps Used for Mill Runs

	Units	Run (a) Kraft pulp	Straw pulp	Blend	Run (b)	Run (c)
Beating degree	°S.-R.	26	48	35	32	21
Draining time	sec.	5.0	23.4	6.2	6.6	4.6
Density	g./cc.	0.744	0.818	0.765	0.736	0.725
Stretch	%	4.01	3.70	4.56	3.83	3.86
Breaking length	m.	6690	6380	6780	7210	6500
Calcd. breaking energy	cm.-kg.	3.41	2.93	3.95	3.48	3.17
Bekk breaking energy	cm.-kg.	3.72	3.29	4.52	3.76	3.46
Absolute burst energy	kgm. 10^{-4}	681	543	798	724	632
Burst factor		68.0	46.4	66.6	67.0	63.2
Tear factor		113	38	96	102	120
Folding endurance	No.	1700	350	1480	1300	1180
Gurley porosity	sec.	22	362	61	68	9

if short-fibered pulp is available. This applies to our case in particular, as straw pulp is easier to beat and, on account of its high content of hemicelluloses, has a bonding action which is greater than other short-fibered pulps.

Gumming Paper

We can state that the addition of small percentages of straw pulp to furnishes for M. F. and M. G. papers (particularly low weight papers) for gumming is as important and useful as in kraft bag papers.

In fact, the small pinholes of the paper caused by the suction boxes and suction roll let gum pass through from the other side of the sheet. This is an extremely serious inconvenience occurring during the application of the gum, as it compels the making of frequent stops in order to clean the roll under the paper and, moreover, when using gummed paper, it allows the gum to pass through, thus rendering the tape sticky.

Such a phenomenon can be fully corrected by reducing paper porosity, this latter being exactly proportioned by a proper addition of straw pulp. When the papermaker does not have that pulp available, he has usually recourse to a very high hydration, which causes two inconveniences, namely: (1) a slowing down of the machine speed; (2) the production of a hard and consequently brittle quality of paper. Percentages of straw pulp ranging from 15 up to 30% permit production of paper that is not excessively brittle and has the proper porosity so that it is not penetrated by gum during both manufacture and use.

Asphalting Paper

As regards paper designed for asphalting, the problem is to be considered as put forward more or less in the same terms. The presence of pinholes is to be absolutely avoided, as they allow the fused asphalt to pass through the sheet thus forming small drops on the other side. It is also necessary for the sheet to be properly formed not only for esthetical reasons but essentially for technical ones. The cloudy paper absorbs a great quantity of asphalt so that the layer which remains between the laminated sheets results thinner in the most cloudy points and acts consequently less efficiently as a barrier against moisture.

Percentages of straw pulp varying between 10 and 25% render the paper free of pinholes, less porous and better formed.

Furthermore, it could be proved that straw pulp, on account of its characteristics, shows a better asphalt resistance, thus absorbing a lesser quantity of the same, and rendering the layer of the product between the two sheets of paper, thicker, more homogeneous, and consequently more efficient.

CONCLUSIONS

Our study has proved that the presence of small quantities of unbleached straw pulp in a furnish based on kraft pulp causes a definite improvement in nearly all the strength properties of the paper manufactured with such a furnish, in comparison with the ones which can be obtained from a furnish composed exclusively of kraft pulp.

This improvement can be observed both when the furnish is prepared with the two pulps beaten separately, and when the beating process is carried out on the blend of the two pulps. The improvement is greatest in the case of the breaking length (up to 16% in comparison with the furnish composed only of kraft pulp) and breaking energy (the Bekk breaking energy can even increase by 30%, and the burst absolute energy by 65%) and it is minimum in the case of the burst factor. It is only the tearing resistance, owing to the addition of a short-fibered pulp, that decreases.

The addition of straw pulp allows a considerable saving of energy for the beating process, as it was evidenced in the course of a mill run carried out on a continuously beaten furnish, and it causes an increase in the beating degree of the furnish. However, our long standing mill experience allows us to state that the paper containing straw pulp can be manufactured without difficulty on a modern continuous machine running at the speed of 250 to 280 m. per min. The sheet thus obtained has higher strength characteristics and a better formation than paper of pure kraft pulp and it is quite suitable for bag production.

The addition of straw pulp is also of a great importance in the making of both gumming and asphalting paper; in fact, the better formation and the lower porosity render it more suitable for these two treatments than usual kraft paper.

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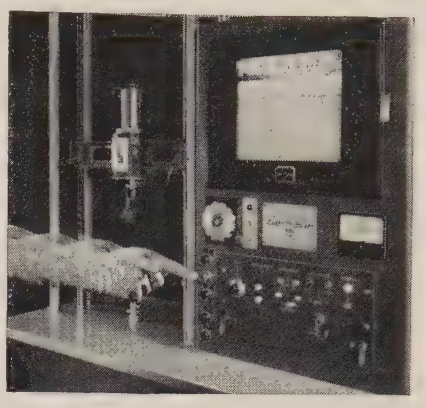

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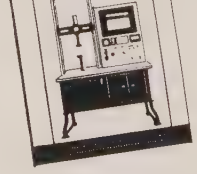

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UNITED STATES PATENTS ON PAPERMAKING

Second Quarter, 1960 — *Compiled by The Institute of Paper Chemistry*

The following list of United States patents has been compiled from the current numbers of the Official Gazette of the United States Patent Office. Because, as a rule, only one claim is published in the Gazette, it is not claimed that the list is complete; also, it is possible that the list may contain some patents that do not apply specifically to pulp and paper manufacture. Copies of any of the following patents may be obtained from the United States Patent Office, Washington 25, D. C., by sending twenty-five cents for each patent desired. Or, those desiring the patents on *microcards* should write to The Institute of Paper Chemistry, Appleton, Wis.

April 5, 1960

Arneson, Edwin L. Can packaging machine. U. S. patent 2,931,152. Filed June 30, 1958. 10 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 53-209.] A paperboard blank is wrapped and locked about a single row of cans.

Burgmer, Josef. Writing block chain. U. S. patent 2,931,666. Filed Nov. 16, 1955. 5 claims. [Cl. 282-11.5.] Improved means are provided for joining a number of sets of manifold forms to form continuous manifolded stationary.

Clark, Carleton L. Conditioning papermaking stock. U. S. patent 2,931,503. Filed April 21, 1953. 12 claims. Assigned to Clark & Vicario Corp. [Cl. 209-211.] A vortex-type dirt separator for paper stock is designed to accomplish deaeration as well as dirt removal.

Clark, James d'A. Apparatus and method for producing fibrous structures. U. S. patent 2,931,076. Filed Nov. 23, 1948. 19 claims. Assigned to Fibrofelt Corp. (Cl. 19-156.] A fibrous mat is formed by air-laying methods.

Cunningham, William A., and Pucher, Leo E. Electric battery plate. U. S. patent 2,931,846. Filed Sept. 10, 1956. 4 claims. Assigned to The Elec. Storage Battery Co. [Cl. 136-30.] Carboxymethylcellulose is used.

Daniels, Wilbert P. Carton closing machine. U. S. patent 2,931,153. Filed March 25, 1955. 8 claims. Assigned to Green Bay Box Co. [Cl. 53-374.] A semiautomatic machine completes the closing and sealing of a partially erected and filled carton.

David, Leonard. Signature feeding devices. U. S. patent 2,931,646. Filed July 23, 1958. 7 claims. [Cl. 271-10.]

Durso, Donald F. Production of cellulose products. U. S. patent 2,931,734. Filed July 18, 1958. 12 claims. Assigned to the Buckeye Cellulose Corp. [Cl. 106-123.] Certain tall oil-based surfactants are added to dissolving pulp to increase the filterability of viscose made therefrom.

Frank, Anton R., and Giles, William H. Article feeding mechanism. U. S. patent 2,931,487. Filed Dec. 8, 1958. 5 claims. Assigned to Van Buren Machine Corp. [Cl. 198-232.] A wrapping machine is provided with means to feed articles to be wrapped and to stop the machine if the article supply stops.

Goms, Richard H. Method of making a molded overlay panel structure of low moisture absorption. U. S. patent 2,931,750. Filed Aug. 30, 1954. 9 claims. Assigned to Whirlpool Corp. [Cl. 154-110.]

Hilliard, David P. Remailable billing envelopes. U. S. patent 2,931,559. Filed Aug. 23, 1954. 1 claim. Assigned to Envo-Bill Corp. [Cl. 229-73.]

Hoffman, William A., Janosik, James P., and Broeck, James S. T., Jr. Fresh meat package and method. U. S. patent 2,931,732. Filed Dec. 24, 1957. 6 claims. Assigned to E. I. du Pont de Nemours & Co. [Cl. 99-174.] A coated cellophane meat wrapper is provided.

Huck, William F. Measurement and control of web tension. U. S. patent 2,931,962. Filed Oct. 18, 1957. 6 claims. Assigned to Huck Co. [Cl. 318-6.]

Humphner, Ferdinand W. Machine for dispensing and severing draw tape. U. S. patent 2,931,419. Filed Aug. 5, 1954. 17 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 154-1.7.]

Ignell, Rolf L. Method and apparatus for the continuous production of drinking straws and the like. U. S. patent 2,931,278. Filed July 12, 1957. 4 claims. [Cl. 93-80.] Spiral-wound waxed-paper drinking straws are continuously formed.

Kine, Benjamin B., and Matlin, Nathaniel A. Bonded nonwoven fibrous products and methods for making them. U. S. patent 2,931,749. Filed Aug. 13, 1956. 15 claims. Assigned to Rohm & Haas Co. [Cl. 154-101.] Certain acrylic polymers are used as binders for nonwoven fabrics of cellulosic or synthetic fibers.

LaBombard, Leon E. Folder belt apparatus. U. S. patent 2,931,277. Filed Nov. 25, 1958. 10 claims. Assigned to The International Paper Box Machine Co. [Cl. 93-52.] Box blanks are folded.

Loderhose, Richard E. Record jacket with detachable photographs. U. S. patent 2,931,557. Filed June 25, 1958. 6 claims. [Cl. 229-70.]

Long, David M. Method and apparatus for forming fibrous glass. U. S. patent 2,931,422. Filed Oct. 26. 1954. 5 claims. Assigned to Owens-Corning Fiberglas Corp. [Cl. 154-29.]

McGihon, Leonard. Carton package. U. S. patent 2,931,490. Filed Jan. 8, 1954. 1 claim. Assigned to King Sales & Eng. Co. [Cl. 206-65]. An openside can carton is provided.

Matern, Rudolph A. Carton with sliding closure flap. U. S. patent 2,931,554. Filed Aug. 6, 1958. 1 claim. [Cl. 229-17.] This is a cigarette carton.

Matoba, Hisashi. Apparatus for producing a pressed pattern in paper. U. S. patent 2,931,064. Filed Sept. 10, 1957. 1 claim. [Cl. 18-35.]

Messing, Hjalmar S. Grinding device for the breaking down of wood fibers. U. S. patent 2,931,586. Filed Aug. 16, 1957. 7 claims. Assigned to American Defibrator, Inc. [Cl. 241-256.] Various structural improvements are made in a defibrator for woody and the like materials.

Müller, Paul A. Crimped flat material for filter plugs for cigarettes. U. S. patent 2,931,748. Filed April 18, 1955. 5 claims. [Cl. 154-46.] A filter plug is formed from a web of paper which has been mechanically deformed in a specified manner.

Mueller, Paul A. Rod-shaped filter element. U. S. patent 2,931,364. Filed Nov. 22, 1957. (Divided; original filed April 18, 1955.) 1 claim. [Cl. 131-208.] A cigarette filter formed of paper elements is described.

Muise, Herbert D. Tray. U. S. patent 2,931,556. Filed Jan. 13, 1958. 3 claims. Assigned to Continental Can Co., Inc. [Cl. 229-34.] Stackable paperboard bread trays are provided.

Newman, Douglas A. Transfer medium and method of making. U. S. patent 2,931,752. Filed Sept. 16, 1953. 2 claims. Assigned to Columbia Ribbon & Carbon Mfg. Co. [Cl. 162-172.] An on-machine coating process is used to make carbon paper.

Nystrand, Ernst D. Web winding mandrel. U. S. patent 2,931,590. Filed Dec. 10, 1956. (Divided; original filed May 12, 1955.) 2 claims. Assigned to Paper Converting Machine Co., Inc. [Cl. 242-72.] A machine for slitting and rewinding toilet paper webs is provided with an improved mandrel for supporting the small rolls as they are wound.

Osterberg, Carl T. Can pack, carrier tube, and blank. U. S. patent 2,931,492. Filed Dec. 20, 1955. 4 claims. Assigned to Cornell Paperboard Products Co. [Cl. 206-65.] A wrap-around blank for forming an open-end carrier for cans is provided with tabs for retaining the cans in the carrier.

Park, Arthur D. Method of making an acoustical panel. U. S. patent 2,931,736. Filed Aug. 27, 1958. 6 claims. Assigned to Armstrong Cork Co. [Cl. 117-9.] Fissured acoustical board is provided with a coating including metallic flakes and an adhesive.

Pfohl, Louis H. Container. U. S. patent 2,931,493. Filed March 6, 1958. 10 claims. Assigned to Design Center, Inc. [Cl. 206-78]. A container for spectacles includes a plastic dome and a paperboard bottom piece, and may be attached to a display card.

Pfohl, Louis H. Container. U. S. patent 2,931,494. Filed May 5, 1959. 11 claims. Assigned to Design Center, Inc. [Cl. 206-78.] This is similar to U. S. patent 2,931,493 (April 5, 1960).

Robinson, Preston. High energy storage capacitor. U. S. patent 2,931,961. Filed Feb. 15, 1955. 1 claim. Assigned to Sprague Elec. Co. [Cl. 317-258.] Dielectric-impregnated kraft paper is used for spacers.

Schuller, Werner. Apparatus for the production of a thin sheet or mat from glass fibers. U. S. patent 2,931,421. Filed July 7, 1953. 4 claims. [Cl. 154-27].

Shields, Albert F. Accumulating and straightening device. U. S. patent 2,931,520. Filed Nov. 20, 1958. 18 claims. As-

signed to S & S Corrugated Paper Machinery Co., Inc. [Cl. 214-6.] Newly formed box blanks are conveyed, straightened, and stacked by the conveyor belt system described.

Simeone, Mario J., and Glaser, Eugene. Breaking attachment for slab gum wrapping machines. U. S. patent 2,931,151. Filed Jan. 26, 1958. 8 claims. Assigned to American Chicle Co. [Cl. 53-123.] Individual sticks of gum are broken off from a slab and are wrapped.

Sloan, Arthur W., and Mann, David J. Cellulose nitrate. U. S. patent 2,931,801. Filed Aug. 13, 1954. 2 claims. Assigned to Atlantic Research Corp. [Cl. 260-223.] The ester is claimed in the form of spherical nonporous particles of specified diameter.

Sloan, Arthur W., and Mann, David J. Cellulose nitrate product. U. S. patent 2,931,800. Filed Aug. 13, 1954. 2 claims. Assigned to Atlantic Research Corp. [Cl. 260-223.] This is similar to U. S. patent 2,931,801 (April 5, 1960).

Stalego, Joseph P. Bonded fibrous insulation and method for manufacturing same. U. S. patent 2,931,738. Filed Dec. 10, 1954. 19 claims. Assigned to Owens-Corning Fiberglas Corp. [Cl. 117-126.] Glass fibers are bonded with an alkyd resin and a urea-borate condensate.

Steiner, Charles S., Fritz, Earle, Becktel, Jack M., and Kloster, William H. Defoaming compositions and process. U. S. patent 2,931,780. Filed March 19, 1956. 9 claims. Assigned to Swift & Co. [Cl. 252-321.] A foam inhibitor for use in papermaking is formed from tall oil pitch.

Stewart, Bruce D. Calender for friction, schreiner, embossing, and other services. U. S. patent 2,931,113. Filed May 12, 1959. 2 claims. Assigned to McKiernan-Terry Corp. [Cl. 38-49.]

Stratton, Edward B., Jr. Display package. U. S. patent 2,931,495. Filed Oct. 11, 1956. 1 claim. Assigned to National Cleveland Corp. [Cl. 206-80.] A skin pack for writing pens or the like is provided.

Tamarin, Bernard. Packaging. U. S. patent 2,931,553. Filed April 9, 1956. 12 claims [Cl. 229-17.] A cigarette pack is provided with improved rigidity and a sliding closure element.

Taylor, Russell C. Carrying device for containers. U. S. patent 2,931,491. Filed Nov. 30, 1955. 2 claims. Assigned to American Can Co. [Cl. 206-65.] Adhesive tape is used to unitize two flat-top milk cartons and a handle device is provided.

Thomasma, John C., and Thomasma, Charls W. Dispenser for paper blanks. U. S. patent 2,931,536. Filed Nov. 25, 1955. 5 claims. Assigned to Sanitor Mfg. Co. [Cl. 221-41.] Tissue paper toilet seat covers are dispensed.

Thornton, Jesse. Impregnation process. U. S. patent 2,931,737. Filed April 4, 1958. 4 claims. Assigned to Hickson's Timber Impregnation Co. (G.B.) Ltd. [Cl. 117-116.] Cellulosic insulation board is impregnated with a liquid impregnant so that the impregnant is contained primarily in the surface areas of the board.

Torstenson, Stig A., and Emmert, Ernest G. Apparatus for determining absorption and liquid penetration of paper. U. S. patent 2,931,977. Filed Oct. 19, 1955. 8 claims. Assigned to The Standard Register Co. [Cl. 324-65.]

Van Antwerpen, Martin. Machine for forming cushioning tongues in shock absorbing strips. U. S. patent 2,931,275. Filed March 25, 1958. 3 claims. [Cl. 93-1.] The strips are multi-ply board strips of use in cushioning the edges of glass sheets.

Zalkind, Joseph. Device for separating interleaved carbons. U. S. patent 2,931,551. Filed May 5, 1955. 7 claims. [Cl. 225-93]. A small manually operated device removes the carbons from a set of manifold stationery.

Zalkind, Joseph. Devices for separating and sorting manifold sets. U. S. patent 2,931,552. Filed March 14, 1957. 5 claims. [Cl. 225-101.]

Zalkind, Joseph. Mailable map holder. U. S. patent 2,931,558. Filed Sept. 13, 1957. 5 claims. [Cl. 229-72.]

Zerlin, Hans. Methods of and means for producing, processing, and for treating articles. U. S. patent 2,931,276. Filed Jan. 29, 1959. 7 claims. Assigned to Jagenberg-Werke A.-G. [Cl. 93-39.1.] Paper blanks are moved along two sequential concentric paths located in a common plane while container-forming operations are conducted on the blanks.

April 12, 1960

Arneson, Edwin L. Bottle carrier. U. S. patent 2,932,424. Filed Aug. 19, 1957. 9 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 220-113.]

Baumgartner, Doyle M. Carton holder. U. S. patent 2,932,423. Filed Dec. 5, 1956. 2 claims. [Cl. 220-85.] A plastic holder is provided for a gable-top milk carton.

Blake, Edward S. Detergent compositions. U. S. patent 2,932,616. Filed Feb. 19, 1957. 7 claims. Assigned to Monsanto Chemical Co. [Cl. 252-135.] Carboxymethylcellulose is used.

Curtis, Russell H. Apparatus and method for making fibrous tubular bodies. U. S. patent 2,932,604. Filed July 29, 1949. 4 claims. Assigned to Hawley Prods. Co. [Cl. 162-228.] A filter element is made.

Day, George D. Heated shell drum dryers. U. S. patent 2,932,091. Filed Oct. 8, 1956. 9 claims. [Cl. 34-124.]

Drese, Wilhelm. Apparatus for filling, folding, and closing containers of paper, cardboard, or the like carton-forming material. U. S. patent 2,932,140. Filed July 7, 1958. 10 claims. Assigned to Jagenberg-Werke A.-G. [Cl. 53-266]. Gable-top milk cartons are filled and sealed.

Freeman, Claude C. Bottle carrier. U. S. patent 2,932,425. Filed Jan. 22, 1959. 1 claim. Assigned to Container Corp. of Am. [Cl. 220-113.]

Fry, Horace P., Jr. Sheet coating means with safety clutch. U. S. patent 2,932,276. Filed May 31, 1956. 3 claims. Assigned to American Viscose Corp. [Cl. 118-33.] An improved clutch is provided for the doctor rolls in a machine for coating cellophane.

Gardner, Marvin A., and Ludwig, John H. Apparatus for filling cartons with cottage cheese and the like. U. S. patent 2,932,329. Filed July 11, 1958. 12 claims. Assigned to M. Sanford Abbey. [Cl. 141-132.]

German, Tilghman L., Jr. Spring pressed pivotated stripper means for use with rotary cutter. U. S. patent 2,932,228. Filed Jan. 2, 1958. 4 claims. Assigned to Greenwood Eng. Co., Inc. [Cl. 83-114]. This device is for use in a printer-slotter.

Glaser, David, and Wittcoff, Harold. Thixotropic coating vehicle containing a short oil alkyd resin and a copolymer polyamide resin. U. S. patent 2,932,623. Filed April 2, 1956. 4 claims. Assigned to General Mills, Inc. [Cl. 260-22.] Tall oil fatty acids are used in forming a vehicle for paints.

Hawley, Don M., and Williams, John C. Process of preparing felted products containing hydratable and nonhydratable fibers. U. S. patent 2,932,601. Filed Nov. 12, 1954. 21 claims. Assigned to Hawley Prods. Co. [Cl. 162-145.]

Holgersson, Sigbjörn, P. H. E., and Groth, Kjell, J. I. Method of preventing depositions of pitch from sulfite pulp. U. S. patent 2,932,602. Filed June 13, 1955. 3 claims. Assigned to Kopparfors AB. [Cl. 162-158.] Up to 0.1% of a cationic surfactant is added to the pulp.

Hope, David G., Filipowicz, Edwin, A., Renard, Winford G., and Wiggins, Robert B. Dispensing devices for paper towels. U. S. patent 2,932,426. Filed March 18, 1955. 3 claims. Assigned to Fort Howard Paper Co. [Cl. 221-36.] This is a wall-mounted mechanism.

Johnnides, James D. Flower display holder. U. S. patent 2,932,384. Filed April 4, 1957. 3 claims. [Cl. 206-45.33.] The holder is of paperboard; after assembly with flowers, the unit may be overwrapped in cellophane.

Keeler, Thelma H. Game book. U. S. patent 2,932,095. Filed Feb. 25, 1957. 2 claims. [Cl. 35-26.] A child's game book comprises a bound assembly of paper and carbon paper sheets.

La Buff, Hugh P., and Shinal, Joseph B. Image reproduction device screen. U. S. patent 2,932,570. Filed Jan. 23, 1956. 1 claim. Assigned to Sylvania Electric Prods., Inc. [Cl. 96-35.] Cellulose nitrate is used in coating a TV picture tube.

Leslie, Robert S. Bag filling apparatus with provision for predetermining package size. U. S. patent 2,932,139. Filed April 22, 1957. 4 claims. Assigned to Kenfield Corp. [Cl. 53-188.]

Mau, Earl G. Roll paper dispensers. U. S. patent 2,932,-463. Filed Dec. 26, 1956. 1 claim. Assigned 30% to Arnold B. Christiansen and 30% to Forest L. Larsen. [Cl. 242-55.53.] A wall-mounted dispenser for rolls of paper is provided.

Meyer, Edwin W., and Circle, Sidney J. Paper coating compositions and process. U. S. patent 2,932,589. Filed March 12, 1956. 6 claims. Assigned to The Glidden Co. [Cl. 117-156.] The composition includes an aqueous anionic dispersion of at least one acylated protein and a finely divided inert filler.

Morse, Edward A. Applicator pad. U. S. patent 2,932,052. Filed March 15, 1956. 2 claims. Assigned to Personal Prods. Corp. [Cl. 15-209.] A cosmetic applicator pad comprises a wood pulp pad between layers of nonwoven fabrics.

Pearson, Leslie S. Package for transporting paper sheets. U. S. patent 2,932,389. Filed Sept. 16, 1957. 5 claims. Assigned to S. D. Warren Co. [Cl. 206-60.] A wrapping for paper stacked on a pallet is adaptable to different stack sizes.

Pesa, Henry S., and Schleicher, Lowell. Pressure sensitive transfer record sheet. U. S. patent 2,932,582. Filed Feb. 4, 1959. 4 claims. Assigned to The National Cash Register Co. [Cl. 117-36.]

Petersen, Bryon F. Phonograph record extractor. U. S. patent 2,932,387. Filed April 13, 1959. 1 claim. Assigned to Clayton L. Drew. [Cl. 206-56.] A nylon card is used to draw a phonograph record from its envelope.

Powell, Edward L. Process for the production of pulp from bagasse. U. S. patent 2,932,600. Filed Feb. 25, 1953. 2 claims. Assigned to Brown and Root, Inc. [Cl. 162-58.]

Richter, Johan C. F. C. Apparatus for separating used liquor from cellulosic pulp. U. S. patent 2,932,396. 7 claims. Assigned to Aktiebolaget Kamyr. [Cl. 210-152.] A screening apparatus is used.

Rosenbaum, Werner. Low temperature web drier. U. S. patent 2,932,092. Filed May 28, 1956. 6 claims. Assigned to Champlain Co., Inc. [Cl. 34-159.] A printed web is dried rapidly, but at low temperatures.

Saurenmann, William T. Container covering machine. U. S. patent 2,932,141. Filed March 18, 1957. 3 claims. Assigned to Sealright-Oswego Falls Corp. [Cl. 53-314.] A machine is provided for use in filling cylindrical paper containers and applying a cover member to each.

Schiefer, Ernest H. Flat tape applicator. U. S. patent 2,932,421. Filed Dec. 18, 1957. 4 claims. [Cl. 216-20.] A hand-held dispenser applies adhesive tape to a flat surface.

Sindzinski, Willy. Device for opening letter envelopes, bags, or like articles. U. S. patent 2,932,142. Filed March 22, 1956. 4 claims. Assigned to International Standard Electric Corp. [Cl. 53-386.] Bags, cartons, envelopes, and the like are opened by suction means for filling or the like.

Smith, Max M. All paperboard shipping containers for water heaters. U. S. patent 2,932,438. Filed June 25, 1956. 6 claims. Assigned to Crown Zellerbach Corp. [Cl. 229-14.]

Sparling, Earl L. Rigid cardboard gift boxes. U. S. patent Filed July 9, 1956. 1 claim. [Cl. 229-31.]

Sterling, George B. High-fold endurance paper and method of making the same. U. S. patent 2,932,603. Filed March 25, 1957. 6 claims. Assigned to The Dow Chem. Co. [Cl. 162-164.] A terpolymer of butadiene, acrylonitrile, and methyl isopropenyl ketone is added to the pulp.

Tabara, Joseph. Safety cigarette holder made from perforated paper and metal foil. U. S. patent 2,932,301. Filed Jan. 7, 1958. 2 claims. [Cl. 131-174.] The holder is a combination ashtray and disposal unit.

Tennler, Rolf. Intermittent feed, web processing apparatus. U. S. patent 2,932,508. Filed July 1, 1958. 13 claims. Assigned to Firma Fr. Hesser Maschinenfabrik-A.G. [Cl. 271-2.4.]

Thumm, Byron A. Method of producing all skin rayon. U. S. patent 2,932,578. Filed Dec. 5, 1955. 4 claims. Assigned to American Viscose Corp. [Cl. 106-165.] The coagulation modifiers are alkylene oxide adducts of 2-aminopyridine.

Woodrow, Louis J. Discardable dentifrice applicator. U. S. patent 2,932,044. Filed Nov. 3, 1958. 9 claims. [Cl. 15-131.] A disposable toothbrush comprises dentifrice contained in a paper bag and supported on a handle element.

April 19, 1960

Bensel, Duryea. Milk, oil, and fruit container. U. S. patent 2,933,229. Filed May 29, 1958. 1 claim. Assigned 10% to Monte Brice, 10% to Daniel M. Winkler, 5% to Joan Billings, 5% to Frank L. Pellissier, 5% to Roberta Stewart Brice, and 5% to David M. Higer. [Cl. 229-14.] The container comprises a polyethylene bag and an outer liner, assembled to provide dispensing means.

Bugnone, Aldo. Carton. U. S. patent 2,933,232. Filed Feb. 1, 1957. 3 claims. [Cl. 229-41.] A pleated bellows top closure is formed, including a vertical handle element.

Byrd, Gerald J. Dispersant and method of making the same. U. S. patent 2,933,452. Filed Sept. 7, 1956. 6 claims. Assigned to Lignosol Chemicals Ltd. [Cl. 252-353.] A dispersing agent is derived from spent sulfite liquor.

Claybourn, Carlton C., and Kobos, Roman L. Sheet transferring mechanism. U. S. patent 2,933,039. Filed Aug. 21, 1958. 8 claims. Assigned to Miehle-Goss-Dexter, Inc. [Cl. 101-183.] Sheets are transferred between impression cylinders of a multi-impression printing press.

Cole, Gerald E. Label dispensing machine. U. S. patent 2,933,216. Filed Dec. 20, 1955. 20 claims. Assigned to Kleen-Stick Prods., Inc. [Cl. 221-73.]

Colgren, Carl T., and Haas, Richard G. Cellular carton. U. S. patent 2,933,231. Filed June 30, 1958. 10 claims. Assigned to KVP Sutherland Paper Co. [Cl. 229-28.] A partitioned egg carton with hinged cover is formed from a single blank.

Davis, Stanley L. Packages. U. S. patent 2,933,182. Filed Feb. 3, 1958. 2 claims. [Cl. 206-42.] An assembly of plastic and paperboard forms a pack for lighter flints.

Fahrenbach, Wolfgang B., Tonna, Arthur J., and Sariotti, Victor A. Tray packing and forming machine. U. S. patent 2,932,929. Filed Jan. 8, 1959. 21 claims. Assigned to Burgermeister Brewing Corp. [Cl. 53-159.] A paperboard tray is formed about the lower portions of four six-pack can carriers.

Flanigan, Edwin B., and Flanigan, Katharine H. Cleansing cloth. U. S. patent 2,932,839. Filed Aug. 24, 1953. 2 claims. [Cl. 15-122.] The cloth is an assembly of superposed sheets of paper and soap.

Galer, Merrill F. Coating device, U. S. patent 2,933,061. Filed March 29, 1957. 1 claim. Assigned to Time, Inc. [Cl. 118-3.] A coating is flowed onto a paper web down a flexible blade which also doctors the coating.

Geib, Clarence C. Rectifier and method of making same. U. S. patent 2,933,661. Filed Aug. 5, 1953. 10 claims. Assigned to Fansteel Metallurgical Corp. [Cl. 317-234.] In a selenium rectifier, the selenium layer is mechanically bonded to kraft paper.

Graves, Clare E. Disposable shoe shining pad. U. S. patent 2,932,841. Filed April 28, 1958. 1 claim. [Cl. 15-209.] The pad comprises deposits of shoe-shining material carried on and within a folded sheet of paper.

Green, Frank B. K. Pulp manufacture. U. S. patent 2,933,208. Filed Dec. 18, 1957. 6 claims. Assigned to Sprout, Waldron & Co., Inc. [Cl. 214-17.] Rotary valve means are provided for introducing chips into a continuous digester.

Guyer, Reynolds. Container. U. S. patent 2,933,228. Filed March 28, 1955. 1 claim. Assigned to Waldorf Paper Prods. Co. [Cl. 229-14.] A container is formed from corrugated having no liner sheet on the inside: reinforcing strips of paper are used instead.

Haakh, Hermann, and Rückert, Alfred. Process for fixing pigments on fibrous materials. U. S. patent 2,933,416. Filed April 26, 1955. 6 claims. Assigned to Farbwerke Hoechst A.-G., vormals Meister Lucius & Brüning. [Cl. 117-103.] Paper or textiles are dyed or printed with a heat-drying composition containing the pigment.

Hannon, Donald F. Identification card. U. S. patent 2,932,913. Filed Sept. 30, 1958. 5 claims. Assigned to Laminators Inc. [Cl. 40-2.2.] A paperboard card is laminated between plastic sheets so as to render tampering detectable.

Harker, Charles B. Dispensing device. U. S. patent 2,933,220. Filed July 3, 1957. 3 claims. Assigned to Bartelt Eng. Co. [Cl. 222-352.] A machine is provided for bagging tobacco strands.

Harrington, Robert C., Jr., and Smith, James L. Flameproof cellulose organic acid ester fibers and process for their preparation. U. S. patent 2,933,402. Filed Dec. 12, 1957. 13 claims. Assigned to Eastman Kodak Co. [Cl. 106-15.]

Helmig, Richard W. Sheet gripper element. U. S. patent 2,933,040. Filed Dec. 19, 1958. 2 claims. Assigned to Harris-Intertype Corp. [Cl. 101-412.] A printing press sheet gripper holds the sheets with a positive action.

Hepp, Rudolf. Method and apparatus for the separation of folded layers of paper with a protruding edge. U. S. patent 2,933,312. Filed Nov. 15, 1955. 13 claims. [Cl. 270-54.] The apparatus provided opens a folded sheet of paper so that it can be interleaved with others.

Kirchberger, Michael. Folder packer. U. S. patent 2,933,226. Filed July 21, 1958. 5 claims. [Cl. 225-13.] The device described folds postage stamps within a paperboard folder to provide an assembly for use in a dispensing machine.

Moore, Dwight M., and Field, Howard, Jr. Temperature indicator. U. S. patent 2,932,971. Filed Feb. 11, 1957. 1 claim. Assigned to General Dynamics Corp. (Convair Division). [Cl. 73-356.] Blotting paper is used in forming a device for use in indicating the peak and sustained temperatures to which a specimen may be subjected.

Mustin, Frank H., and Mulcey, Paul A. Solid fuel unit. U. S. patent 2,933,378. Filed Nov. 25, 1957. 6 claims. Assigned to Frank H. Fleer Corp. [Cl. 44-14.] The unit—for home cooking—consists of interconnected charcoal briquettes covered on both sides with paper mache.

Norton, James A. Method for testing oil filter elements. U. S. patent 2,933,604. Filed Sept. 27, 1954. Assigned to General Motors Corp. [Cl. 250-83.] An oil filter of resin-impregnated paper is tested to determine resin migration into the oil.

Reeves, Wilson A., Drake, George L., Jr., and Guthrie, John D. Flame-resistant cellulosic textiles and process of reacting cellulose ether textiles with aziridinyl phosphine oxide or sulfide. U. S. patent 2,933,367. Filed Oct. 29, 1957. 3 claims. Assigned to U. S. Secretary of Agriculture. [Cl. 8-129.]

Salzberg, Harold K., and King, Clifford J. Protein and non-ionic agent compositions. U. S. patent 2,933,406. Filed Sept. 11, 1957. 9 claims. Assigned to The Borden Co. [Cl. 106-125.] A paper-coating adhesive includes a surfactant which releases air bubbles, preventing pinholes in the coated layer.

Scaglione, Paul J. Box spout. U. S. patent 2,933,218. Filed Jan. 7, 1957. 6 claims. [Cl. 222-90.] A metal device cuts an access opening in a carton wall and attaches to the wall as a pour spout.

Schmitz-Hillebrecht, Ernst, and Wolf, Heinz. Process for producing shaped bodies. U. S. patent 2,933,401. Filed Aug. 8, 1956. 6 claims. Assigned to Farbenfabriken Bayer AG.

[Cl. 106-15.] A laminating agent including a fungicide or the like is provided.

Sperouleas, Theodore H. J. Medicated tissue. U. S. patent 2,933,431. Filed March 28, 1957. 18 claims. [Cl. 167-84.] This is a chemical-impregnated tissue paper which releases vapors for the alleviation of distress of ailments of the nose and throat and the like.

Stewart, Basil O., and Schneiter, Henry J. Sound absorptive structure. U. S. patent 2,933,147. Filed Feb. 20, 1957. 2 claims. Assigned to National Gypsum Co. [Cl. 181-33.] Wall-covering materials of varying density and acoustical properties are formed from a mixture of lime, asbestos fiber, foaming agent, and water.

Stobb, Anton R. Method and means for collecting flexible sheets. U. S. patent 2,933,313. Filed Jan. 27, 1958. 15 claims. [Cl. 271-68.] Folded signatures are received and conveyed to a stacking station.

Stobb, Anton R. Method and means for collecting and stacking flexible sheets. U. S. patent 2,933,314. Filed Jan. 27, 1958. 17 claims. [Cl. 271-88.] This is similar to U. S. patent 2,933,313 (April 19, 1960).

Strazdins, Edward. Storage of rosin in molten form. U. S. patent 2,933,486. Filed July 30, 1956. 4 claims. Assigned to American Cyanamid Co. [Cl. 260-97.5.] Crystallization is prevented by reacting the rosin with a small amount of formaldehyde.

Vahle, Raymond. Molded egg carton. U. S. patent 2,933,227. Filed Sept. 25, 1956. 3 claims. Assigned to Continental Can Co., Inc. [Cl. 229-2.5.] An improved cover construction is provided and the carton is designed to be torn apart into two completely enclosed smaller cartons.

Weber, Herbert H. Apparatus for making garment bags and the like. U. S. patent 2,933,023. Filed Feb. 8, 1957. 12 claims. Assigned to H. G. Weber & Co., Inc. [Cl. 93-8.]

Will, Theodore. Book matches. U. S. patent 2,933,181. Filed June 23, 1958. 1 claim. Assigned to Fund-Del, Inc. [Cl. 206-29.] A matchbook has a pop open cover which provides a triple thickness over the front of the book.

Witt, Everett E., and Holt, Frederick W., Jr. Dextran-sulfite liquor solids adhesives. U. S. patent 2,933,405. Filed June 18, 1956. 2 claims. Assigned to The Commonwealth Engineering Co. [Cl. 106-123.]

Witt, Everett E., and Holt, Frederick W., Jr. Dextrin-dextran adhesives. U. S. patent 2,933,407. Filed Aug. 8, 1956. 5 claims. Assigned to The Commonwealth Engineering Co. [Cl. 106-162.] This is for use on paper.

Yezek, Milton. Carton. U. S. patent 2,933,230. Filed Feb. 20, 1957. 3 claims. Assigned to General Foods Corp. [Cl. 229-17.] The top flaps, when opened, form a pouring spout.

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Alsfeld, Max, and Dierichs, Wolfgang. Process for producing wrapping material and casting molds. U. S. patent 2,934,453. Filed Nov. 27, 1956. 2 claims. Assigned to Henkel & Cie. G.m.b.H. [Cl. 117-5.1.] Wrapping paper is coated on one side with a swollen water-insoluble alginate and on the other side with polyethylene.

Bach, John W., and Ford, Frederick L. Sheet feeding and treating. U. S. patent 2,934,009. Filed Oct. 22, 1956. 4 claims. Assigned to Pitney-Bowes, Inc. [Cl. 101-235.] An improved intermittent feeding means is provided in a postage printer.

Basiago, Raymond. Thermal-type marker. U. S. patent 2,934,395. Filed July 9, 1957. 5 claims. Assigned to McGraw-Edison Co. [Cl. 346-139.] This marker is for use in marking heat-sensitive paper.

Bennett, John D., and Walker, Rowland. Wrapping machines. U. S. patent 2,934,196. Filed March 4, 1959. 6 claims. Assigned to Forgrove Machinery Co. Ltd. [Cl. 198-24.] In a packaging line in which confectionery tablets are wrapped, means are provided to remove faulty tablets from the line.

Bergstein, Frank D. Dry gloss precast clay laminated paper and method of making it. U. S. patent 2,934,467. Filed Feb. 7, 1957. 22 claims. Assigned to Bergstein Pkg. Trust. [Cl. 154-97.5.]

Binko, Ivan, and Kolar, Jaroslav. Extracting tanning agent with cation-containing solution with subsequent cation exchange. U. S. patent 2,934,398. Filed Nov. 9, 1955. 11 claims. Assigned to Svit, narodni podnik. [Cl. 8-94.32.] The tanning agent is prepared from pine bark.

Brook, Leonard. Wrapping machines. U. S. patent 2,933,871. Filed Feb. 13, 1958. 4 claims. Assigned to Forgrove Machinery Co. Ltd. [Cl. 53-234.]

Buttery, Kenneth T., and Vander Lugt, Thomas, Jr. Bacon package. U. S. patent 2,934,253. Filed Feb. 6, 1959. 7 claims. Assigned to Sutherland Paper Co. [Cl. 229-40.] A sleevelike container for sliced bacon is provided with reinforcing struts.

Cranston, Albert E., Jr. Method and apparatus for packaging cylindrical articles. U. S. patent 2,933,866. Filed Aug. 27, 1957. 10 claims. [Cl. 53-3.] A number of artificial logs made of sawdust are banded together with paper or the like.

d'Adrian, Vincent L. D. Traffic markers. U. S. patent 2,933,989. Filed Nov. 25, 1955. 7 claims. [Cl. 94-1.5.] Rosin and cellulose ethers are used in formulating a composition for marking road surfaces.

Davis, Roger A., and Hewitt, Alan R. Paper feeding devices. U. S. patent 2,934,339. Filed April 29, 1958. 14 claims. Assigned to International Computers and Tabulators Ltd. [Cl. 271-2.4.] Paper is moved at high speed, one line at a time, through data printing machines.

Gardon, John L., and Leopold, Bengt. Manufacture of lignin derivatives. U. S. patent 2,934,531. Filed Dec. 2, 1957. 2 claims. Assigned to Can. International Paper Co. [Cl. 260-124.] Highly reactive lignin products are prepared from spent sulfite liquor for use in binders in hardboard, wood-particle board, and the like.

Gentry, Hermond G. Means for folding paperboard wrappers about objects to be packaged therein. U. S. patent 2,933,870. Filed Jan. 11, 1957. 2 claims. Assigned to Mead Packaging, Inc. [Cl. 53-209.] A filled sixpack can carrier is formed.

Gentry, Hermond G. Method and means for packaging cans having chines at the ends thereof. U. S. patent 2,933,867. Filed Feb. 24, 1959. 5 claims. Assigned to Mead Packaging, Inc. [Cl. 53-29.] A filled six-pack can carrier carton is formed.

Goodwillie, John E. Adjustable stock inlet for papermaking machines. U. S. patent 2,934,140. Filed Aug. 28, 1956. 2 claims. Assigned to Beloit Iron Works. [Cl. 162-317.]

Gyllenberg, John L. Slab-barking machine having rotatable articulated brush. U. S. patent 2,934,111. Filed April 16, 1956. 9 claims. [Cl. 144-208.]

Haglund, Gustaf. Contacting apparatus for gases and liquids. U. S. patent 2,934,325. Filed Aug. 6, 1956. 4 claims. Assigned to AB Hedemora Verkstäder. [Cl. 261-92.] The apparatus is for use in preparing sulfite cooking liquor.

Hindle, Thomas, Brow, Beardwood, and Race, Edward. Papermakers' drier felts. U. S. patent 2,934,097. Filed Dec. 5, 1957. 13 claims. [Cl. 139-383.] The felt is woven to have high capillarity and a structure such that disintegration of the face does not result in disintegration of the felt as a whole.

Hornbostel, Lloyd. Suction flat box cover perforation. U. S. patent 2,934,143. Filed June 17, 1957. 2 claims. Assigned to Beloit Iron Works. [Cl. 162-351.]

Hottendorf, William J., and Harshman, Chester E. Container flap cutting machine. U. S. patent 2,933,987. Filed Oct. 15, 1957. 6 claims. Assigned to H & C Engineering Corp. [Cl. 93-58.4.]

Ikavalko, Erkki. Apparatus for feeding paper pulp at a continuous rate into a papermaking machine. U. S. patent 2,934,141. Filed Nov. 2, 1955. 3 claims. Assigned to Valmet Oy. [Cl. 162-337.]

Ikavalko, Erkki. Method and apparatus for feeding substantially gas-free paper pulp into a papermaking machine. U. S. patent 2,934,142. Filed Nov. 2, 1955. 5 claims. Assigned to Valmet Oy. [Cl. 162-337.]

Justus, Edgar J. Heat pump system for papermachine driers. U. S. patent 2,933,826. 8 claims. Assigned to Beloit Iron Works. [Cl. 34-86.]

Kramer, Theodore F. Packaging device. U. S. patent 2,934,251. Filed Aug. 2, 1954. 13 claims. Assigned to General Motors Corp. [Cl. 229-14.] A stackable palletizable shipping container of paperboard is provided.

Labine, Roland A. Web feeding device. U. S. patent 2,934,338. Filed Oct. 25, 1956. 10 claims. Assigned to Package Machinery Co. [Cl. 271-2.2.] The web is intermittently fed from a supply roll to a wrapping station.

McDuffie, Orville W. Bag closure and method of opening bags. U. S. patent 2,934,255. Filed Aug. 19, 1955. 1 claim. Assigned to International Paper Co. [Cl. 229-66.]

Meyer-Jagenberg, Günther. Cell structures for use in filling and closing containers. U. S. patent 2,933,869. Filed March 24, 1959. 6 claims. Assigned to Jagenberg-Werke A.G. [Cl. 53-201.] Improved carton supporting and folding means are provided in a machine for filling and closing milk cartons.

Molla, Pietro. Method and joint for forming tubes from corrugated material. U. S. patent 2,934,466. Filed Dec. 28, 1953. 6 claims. Assigned to S.A.F.F.A.-S.pA. Fabbriche Fiammiferi ed Affini. [Cl. 154-83.]

Nestor, Leonard R., and Le Page, Robert A. Production of groundwood pulp. U. S. patent 2,934,279. Filed June 29, 1955. 2 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 241-200.] The wood billets are ground by a belt apparatus, producing relatively long fibers.

Pardee, Edward L. E. Packaged tree. U. S. patent 2,934,204. Filed July 22, 1957. 3 claims. [Cl. 206-46.) A Christmas tree is wrapped in polyethylene film and supported within a paperboard shipping carton.

Pollmann, Max. Mechanism for the filling of cigarette boxes.

U. S. patent 2,933,872. Filed June 10, 1958. 6 claims. Assigned to Hauni-Werke Körber & Co. K.G. [Cl. 53-258.]

Roberson, Cyrus E. Combination jordan and disk refiner for paper stock. U. S. patent 2,934,278. Filed March 14, 1956. 2 claims. Assigned to Noble & Wood Machine Co. [Cl. 241-163.]

Reushoff, Gerhard. Aluminized building material. U. S. patent 2,933,919. Filed May 20, 1958. 1 claim. [Cl. 72-28.] An aluminum foil-paper laminate is included in the assembly.

Schwartzberg, Louis. Composite molded paper pulp egg tray. U. S. patent 2,934,233. Filed July 19, 1956. 1 claim. [Cl. 271-26.5.]

Schwartzberg, Louis. Composite molded paper pulp egg tray. U. S. patent 2,934,233. Filed July 19, 1956. 1 claim. [Cl. 217-26.5.]

Seyforth, Rome C. Hardware package for corner braces and the like. U. S. patent 2,934,205. Filed Oct. 30, 1956. 4 claims. Assigned to Shelby Metal Prods. Co. [Cl. 206-79.]

Shackelford, Jesse J. Feed for box partition assembly device and the like. U. S. patent 2,934,340. Filed Feb. 20, 1959. (Divided; original filed July 21, 1955.) 8 claims. Assigned to Fairmont Box Co. [Cl. 271-44.]

Sproull, Reavis Co., and Hard, Herbert G., Jr. Low power factor capacitor. U. S. patent 2,934,686. Filed April 26, 1955. 2 claims. Assigned to Sprague Elec. Co. [Cl. 317-258.] The dielectric paper used is formed of an unbleached softwood kraft pulp of specified characteristics.

Stark, Martin H. Tube body forming mechanism. U. S. patent 2,933,988. Filed May 22, 1956. 4 claims. [Cl. 93-82.] The machine forms paperboard tubes of a variety of sizes and types.

Sterick, Harrison D. Ingot mold insert mat. U. S. patent 2,933,788. Filed Dec. 12, 1957. 4 claims. [Cl. 22-139.] The mat consists of spirally interwound strips of metal and paper or board.

Stotz, Elmer W. Poulty freezer tray. U. S. patent 2,934,-250. Filed Jan. 27, 1958. 9 claims. Assigned to River Raisin Paper Co. [Cl. 229-6.] A paperboard poultry freezer tray may be stacked while still permitting ventilation.

Stowasser, Heribert. Metallized bandaging material especially for the treatment of wounds. U. S. patent 2,934,066. Filed May 12, 1958. 8 claims. Assigned to Lohmann K.G. [Cl. 128-156.] The bandage comprises a cellulosic fiber felt having a thin metal coating covering the surfaces of the fibers.

Strazdins, Edward. Fortified rosin size and paper sized therewith. U. S. patent 2,934,468. Filed July 30, 1956. 13 claims. Assigned to American Cyanamid Co. [Cl. 162-180.] The size is the saponified product of a rosin-formaldehyde reaction product.

Tonna, Arthur J. Piggyback carton stacker. U. S. patent 2,934,221. Filed April 23, 1958. 2 claims. Assigned to Burgermeister Brewing Corp. [Cl. 214-6.]

Ullger, Joseph W. Folding box. U. S. patent 2,934,254. Filed Aug. 8, 1958. 2 claims. Assigned to William J. Boas and Co. [Cl. 229-41.] A collapsible hatbox is provided.

Valo, Veikko L. Debarking machine having log rotating and advancing wheels and a screw-shaped cutter. U. S. patent 2,94,3112. Filed Nov. 13, 1957. 3 claims. [Cl. 144-208.]

Warp, Harold. Insulating material. U. S. patent 2,934,465. Filed Sept. 19, 1955. 6 claims. Assigned to Flex-O-Glass, Inc. [Cl. 154-45.] An expandable structure of asphalt-laminated paper forms an insulation material for installation between studs of a building.

Wickstrom, John A. Tray insert for packages. U. S. patent 2,934,252. Filed May 11, 1959. 6 claims. Assigned to Mother's Cake & Cookie Co. [Cl. 229-35.] A partitioned paperboard tray is provided as an insert in a cookie pack.

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Aarons, Ralph, Baumgartner, William H., and English, Daniel R. Flame retardant composition. U. S. patent 2,935,471. Filed Sept. 10, 1958. 10 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 252-8.1] The composition provided is of use in flameproofing paper.

Baumel, Joseph. Foldable stereoscopic viewer. U. S. patent 2,934,999. Filed Nov. 17, 1955. 6 claims. [Cl. 88-29.] The viewer is folded from a single paperboard blank.

Belwood, Edwin. School books carryall. U. S. patent 2,935,240. Filed Feb. 12, 1958. 1 claim. [Cl. 229-52.] This carrier is made of a single paperboard blank.

Biskup, John, Johnson, Spencer, and Wetterau, Paul C. Enamel paint and method of producing a surface covering resembling a tiled surface. U. S. patent 2,935,417. Filed April 17, 1956. 17 claims. Assigned to Congoleum-Nairn, Inc. [Cl. 117-15.] The coating provided is for application to a paper backing in the manufacture of floor and wall coverings.

Brady, Charles V. Bag. U. S. patent 2,935,241. Filed June 21, 1957. 4 claims. Assigned to Bemis Bro. Bag. Co. [Cl. 229-53.] A plastic or coated paper bag is provided for packaging milk or other fluids.

Caldwell, Carlyle G., and Wurzburg, Otto B. Method of making paper containing a starch ether and product produced thereby. U. S. patent 2,935,436. Filed May 9, 1957. 11 claims. Assigned to National Starch and Chem. Corp. [Cl. 162-175.] The ethers, used as pulp additives, are dialkyl amino alkyl ethers of starch.

Collier, Alan. Production of hard and flexible microcrystalline waxes. U. S. patent 2,935,457. Filed Aug. 6, 1957. 11 claims. Assigned to The British Petroleum Co. Ltd. [Cl. 208-25.] The flexible wax is of use in coating and laminating.

Cook, Ralph L., and Andrew, Eugene A. Nitrocellulose lacquers. U. S. patent 2,935,414. Filed May 22, 1958. 5 claims. Assigned to Olin Mathieson Chemical Corp. [Cl. 106-183.]

Cosby, Clarence C., Jr., Harrow, Lee S., and Phalen, Jean H. Cigarette package. U. S. patent 2,935,228. Filed Jan. 13, 1958. 3 claims. Assigned to Philip Morris, Inc. [Cl. 221-247.] A flip-top box is provided with means to open and lift the top and partially eject the first cigarettes of the pack.

Craig, William L. Paper and method of making same. U. S. patent 2,935,438. Filed March 2, 1956. 9 claims. Assigned to R. T. Vanderbilt Co., Inc. [Cl. 162-181.] Calcium chloride and sodium silicate are reacted, the product is reacted with aluminum sulfate, and the product is used as a paper filler.

de Million-Czarnecki, Gabryel. Dispensing package. U. S. patent 2,935,192. Filed Jan. 15, 1958. 8 claims. Assigned to Container Corp. of America. [Cl. 207-58.] A roll of sheet material is supported for dispensing in a carton having a triangular cross section.

Dunbar, Alver, Hausmann, George J., and Johnson, Bayard S. Self-sealing asphalt shingle and process for making same. U. S. patent 2,935,416. Filed June 10, 1957. 11 claims. Assigned to Franklin Research Co. [Cl. 117-4.]

Ecclestone, Awrey. Pocket book cover. U. S. patent 2,-935,337. Filed Aug. 4, 1958. 3 claims. [Cl. 281-34.] An assembly of paperboard and plastic forms a device which may be attached to a paper-backed book to simulate a more expensive binding.

Engleson, Harry E., and Sramek, Elmer D. Article detecting mechanism. U. S. patent 2,934,869. Filed Nov. 8, 1957. 4 claims. Assigned to F. B. Redington, Co. [Cl. 53-57.] Malfunction stop-feed means are provided in a cartoning machine.

Harris, Edward P. Apparatus for making tubing. U. S. patent 2,935,003. Filed Feb. 13, 1956. 1 claim. Assigned to General Motors Corp. [Cl. 93-80.] A web of paper is wound about a mandrel and mechanically deformed to provide a corrugated tubing.

Heine, Henry W. Manufacture of acoustic fireproof tiles. U. S. patent 2,934,789. Filed Sept. 3, 1958. 2 claims. [Cl. 18-47.5.] Sawdust is included in a ceramic molding composition.

Higgin, Wilfrid L. Knockdown bottle display stand. U. S. patent 2,935,205. Filed Jan. 15, 1959. 9 claims. Assigned to Nehi Beverage Co. [Cl. 211-49.] Paperboard separator sheets are used.

Kasten, Walter, and Rohn, Abbott M. Method of forming filter endcaps. U. S. patent 2,934,791. Filed Feb. 7, 1956. (Divided; original filed Oct. 22, 1953.) 2 claims. Assigned to Bendix Aviation Corp. [Cl. 18-59.] Plastic endcaps are molded to a pleated paper filter unit.

King, Ellis G., and Adolphson, Carl. Drilling fluid composition and process. U. S. patent 2,935,473. Filed May 25, 1959. 121 claims. Assigned to Puget Sound Pulp and Timber Co. [Cl. 252-8.5.] Lignin compounds from spent pulping liquors are used in making a well-drilling fluid.

King, Ellis G., and Adolphson, Carl. Process of improving the effectiveness of the components of spent sulfite liquor and the products thereof. U. S. patent 2,935,504. Filed Oct. 10, 1955. 27 claims. Assigned to Puget Sound Pulp and Timber Co. [Cl. 260-124.] A drilling mud additive is prepared.

Klause, Karl, and Grupe, Frederick A., Sr. Apparatus for applying tear card to inner flap of wrapped package. U. S. patent 2,934,870. Filed Sept. 25, 1958. 4 claims. Assigned to American Can Co. [Cl. 53-73.]

Koehler, Karl E. Collapsible pyramid structures and blanks therefor. U. S. patent 2,935,238. Filed Jan. 30, 1958. 19 claims. [Cl. 229-22.] The structure, formed of paperboard, is designed for use as a greeting card.

Linsk, Jack. Oxygen-containing thermoplastic compositions. U. S. patent 2,935,415. Filed Oct. 28, 1955. 5 claims. Assigned to Standard Oil Co. [Cl. 106-189.] A plasticized cellulose acetate composition is provided.

Marsh, Roy W. Self-locking, pliable sheet construction or the like. U. S. patent 2,935,239. Filed Nov. 4, 1957. 1 claim. [Cl. 229-35.] A traylike paperboard container or similar structure is provided with improved corner-locking means.

Martin, William T. Machines for unloading jars or the like

from cartons. U. S. patent 2,935,217. Filed July 29, 1957. 4 claims. Assigned to Beech-Nut Life Savers, Inc. [Cl. 214–311.]

Mitchell, Robert M., Junker, Wesley F., and Torongo, Albert H., Jr. Bottle case. U. S. patent 2,935,221. Filed Aug. 11, 1958. 4 claims. Assigned to National Brewing Co. [Cl. 220-4.] Reusable ends and bottom are molded of plastic; the sides are replaceable paperboard.

Olson, Kenneth E. Match book. U. S. patent 2,935,184. Filed June 11, 1958. 1 claim. [Cl. 206-29.] A cavity is provided in the base end of a match book for striking the matches.

Pasachall, Eugene F. Preparation of starch derivatives containing nitrogen. U. S. patent 2,935,509. Filed Aug. 21, 1956. 2 claims. Assigned to Corn Prods. Co. [Cl. 260-233.3.] Starch carbamates of use in water-proofing paper are prepared.

Patt, William. Feeding of sugar tablets to wrapping machines. U. S. patent 2,935,216. Filed Dec. 24, 1958. Issued May 3, 1960. 2 claims. [Cl. 214-310.]

Pfeiffer, Fred B. Method of packaging and sheet material for same. U. S. patent 2,934,865. Filed July 8, 1957. (Divided; original filed Feb. 3, 1954.) 9 claims. Assigned 50% to Crossan, J. R. [Cl. 53-22.] A method is provided for crinkling paper, foil, or plastic to form a packaging material.

Robinson, Bailey P., Jr. Mechanism for producing a manifolding assembly interlock. U. S. patent 2,935,002. 1 claim. Filed June 28, 1957. [Cl. 93-1.1.] Tongues are cut in the margins of superposed webs of manifold paper so as to cause them to lock together.

Rose, Thomas E. Machines for unloading jars or the like from cartons. U. S. patent 2,935,215. Filed April 18, 1957. 8 claims. Assigned to Beech-Nut Life Savers, Inc. [Cl. 214-304.]

Ross, Sidney D., and Allison, William M. Stabilized dielectric compositions. U. S. patent 2,935,667. Filed Dec. 5, 1955. 4 claims. Assigned to Sprague Electric Co. [Cl. 317-258.] The paper spacers of a capacitor are impregnated with glycerides of fatty acids, and benzil.

Schmitz, Peter M., and Duren, Kreis. Apparatus for reeling a web of material. U. S. patent 2,935,272. Filed Sept. 6, 1957. 6 claims. Assigned to O. Dorries A.G. [Cl. 242-65.]

Seidler, Leon S. Cigarette packages. U. S. patent 2,935,-187. Filed Oct. 8, 1958. 6 claims. [Cl. 206-41.5.] A cutting string device is provided so that the cigarettes may be cut into different lengths as desired by the user.

Shedd, Hugh P. Calendar construction. U. S. patent 2,-934,845. Filed May 19, 1959. 4 claims. Assigned to Shedd-Brown, Inc. [Cl. 40-119.] An improved sprial binding for a wall-mounted calendar is provided.

Shwayder, Ben. Method of forming multiple curved panels. U. S. patent 2,934,790. Filed July 5, 1957. 1 claim. Assigned to Shwayder Bros. Inc. [Cl. 18-56.] Compound curves are formed in hardboard panels.

Sottysiak, Joseph. Stability of photographic paper emulsion coatings. U. S. patent 2,935,405. Filed Aug. 25, 1955. 6 claims. Assigned to General Aniline & Film Corp. [Cl. 96-110.]

Stein, Elmer L. Advertising display. U. S. patent 2,934,-846. Filed March 13, 1958. 1 claim. Assigned to Eye-Beam Displays, Inc. [Cl. 40-125.] A flanged-edge display panel with supporting means is constructed to improve the effective stiffness of the panel.

Tasker, Frederick. Self-positioning siphon scraper for drier drums. U. S. patent 2,934,831. Filed Oct. 14, 1957. 3 claims. Assigned to Howard Smith Paper Mills Ltd. [Cl. 34-125.] The head of the siphon is maintained in scraping position against the interior cylindrical wall of a paper machine drier so as to remove condensate as soon as it is formed.

Taylor, Louis B. Method of making a pigment-filler paper. U. S. patent 2,935,437. Filed Nov. 20, 1953. 7 claims. Assigned to Columbia-Southern Chem. Corp. [Cl. 162-181.] Calcium silicate and sodium bicarbonate are added to a pulp slurry and reacted therein.

Thatcher, Herbert A. Apparatus for packing and wrapping food products. U. S. patent 2,934,873. Filed Nov. 12, 1957. 5 claims. [Cl. 53-370.] Meats are packed into cellulosic casings.

Then, Edward O. Carrying handle for containers. U. S. patent 2,935,355. Filed Aug. 9. 1957. 5 claims. Assigned to American Can Co. [Cl. 294-87.2.] A paperboard handle attaches to two flat-top milk cartons banded together with a paper band or the like.

Vineberg, Joseph H. Packaging device. U. S. patent 2,935,181. Filed Oct. 21, 1957. 1 claim. [Cl. 206-7.] A paper bag, including a paperboard hanger element, is provided for use in packaging dresses and the like.

Vogt, Clarence W. Packaging fluent products. U. S. patent 2,934,867. Filed July 30, 1956. 8 claims. [Cl. 53-30.] Packets formed of thermoshaped plastic are reinforced with paperboard.

Watts, Reginald A. Package collector for coin package machine. U. S. patent 2,934,871. Filed March 10, 1958. 4 claims. Assigned to Automatic Coinwrapping Machine Corp. [Cl. 53-248.]

Will, Theodore. Snap-up book match folders. U. S. patent 2,935,185. Filed March 5, 1959. 2 claims. Assigned to Fund-Del Inc. [Cl. 206-29.]

Wise, Robert T. Apparatus for packaging an edible article. U. S. patent 2,934,872. Filed Sept. 3, 1957. 9 claims. Assigned to Drumstick, Inc. [Cl. 53-296.] An ice cream cone is packed within a conical paper container.

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Alexander, George. Heat-resistant resins and laminates. U. S. patent 2,936,260. Filed July 2, 1956. 9 claims. Assigned to General Electric Co. [Cl. 154-128.] A modified phenol-formaldehyde resin is provided for laminating paper and the like.

Ayers, Joseph W. Linoleum. U. S. patent 2,936,243. Filed June 30, 1955. 17 claims. Assigned to J. W. Ayers & Co. [Cl. 106-123.] Tall oil derivatives are used in a linoleum composition.

Ayers, Joseph W. Tall oil linoleum. U. S. patent 2,936,244. Filed June 30, 1955. 21 claims. Assigned to J. W. Ayers & Co. [Cl. 106-123.]

Bidwell, Howard. Apparatus for the treatment of paper stock. U. S. patent 2,936,128. Filed Dec. 8, 1955. 11 claims. [Cl. 241-157.] The apparatus accomplished fiberizing and fibrillation action on paper stocks, particularly rag stocks.

Brown, Donald E. Mobile whole-tree wood-chipper unit. U. S. patent 2,936,008. Filed April 17, 1957. 6 claims. Assigned to The Bauer Bros. Co. [Cl. 144-162.]

Burt, Robert V. Premium feeder. U. S. patent 2,935,827. Filed June 24, 1957. 6 claims. Assigned to The Procter & Gamble Co. [Cl. 53-60.] The machine provided feeds premiums into cartons of cereal or soap or the like.

Childers, Robert A. Weatherproof jacketing for instulation. U. S. patent 2,936,259. Filed Jan. 24, 1956. 6 claims. Assigned to Childers Mfg. Co. [Cl. 154-44.] The jacketing (for piping) comprises an outer sheet of thin aluminum and an inner asphalt-laminated kraft paper.

Davidson, William W. Collator. U. S. patent 2,936,167. Filed March 29, 1957. 10 claims. [Cl. 270-58.]

De Blaere, William H. Collapsible carton. U. S. patent 2,936,104. Filed June 1, 1956. 5 claims. Assigned to Bloomer Bros. Co. [Cl. 229-51.] An automatic bottom side-opening ice cream carton is designed to permit opening without collapsing.

Dunning, Robert M. Can carriers. U. S. patent 2,936,069. Filed Nov. 8, 1957. 5 claims. Assigned to Waldorf Paper Prods. Co. [Cl. 206-65.] This is an open-end paperboard can carrier with improved means for holding the cans in the sleeve.

Eimer, David R. Gift package wrappings. U. S. patent 2,936,101. Filed April 21, 1958. 3 claims. Assigned 50% to Martin Eimer. [Cl. 229-14.] Inner and outer paper wrapping sheets are attached to a carton for use in packaging gifts.

Field, Charles W. Animal bed (construction). U. S. patent 2,936,102. Filed April 18, 1956. 8 claims. [Cl. 229-33.] The bed is made of corrugated paperboard.

Francis, Frederick G., and Seaward, John A. Transfer sheets for forming thermosensitive copies. U. S. patent 2,936,247. Filed June 5, 1958. 2 claims. Assigned to Caribonum Ltd. [Cl. 117-36.] A colored (nonblack) transfer sheet is provided for use in thermographic duplicating.

Ginaven, Marvin E. Fiberizing press. U. S. patent 2,935,-931. Filed Dec. 17, 1956. 9 claims. Assigned to The Bauer Bros. Co. [Cl. 100-117.] Improvements such as better liquor-removing means are provided in a screw press for fiberizing wood chips.

Goss, Harold J. Apparatus for erecting and closing cartons. U. S. patent 2,935,918. Filed Sept. 25, 1956. 7 claims. Assigned to The International Paper Box Machine Co. [Cl. 93-53.] Both operational steps are conducted without requiring a carton-transfer step in the manufacturing line.

Herrick, William W., and Tangard, Einar W. Document feeding and timing device. U. S. patent 2,936,170. Filed Dec. 10, 1956. 10 claims. Assigned to Pitney-Bowes, Inc. [Cl. 271-12.]

Hochmuth, Frank W. Chemical recovery unit. U. S. patent 2,936,215. Filed Dec. 19, 1956. 2 claims. Assigned to Combustion Engineering, Inc. [Cl. 23-48.] A multistage direct contact evaporator is provided for spent pulping liquor.

Inman, William H. Collapsible carton. U. S. patent 2,936,-103. Filed April 18, 1956. 5 claims. Assigned to Bloomer Bros. Co. [Cl. 229-51.] An automatic bottom side-opening ice cream carton is designed so that it may be opened without collapsing.

Kingery, Marion R. Fish bait containers. U. S. patent 2,935,858. Filed Aug. 9, 1957. 1 claim. [Cl. 62-371.] An outer container holds ice, an inner container of paper mache holds the bait.

La Marche, Marcel. Disposable waste container for automo-

biles. U. S. patent 2,936,105. Filed Nov. 13, 1956. 3 claims. [Cl. 229-53.] The container, formed of paperboard, attaches to the auto toe pad.

Laufer, Frédéric. Presses for processing paper and cardboard. U. S. patent 2,935,932. Filed April 3, 1957. 7 claims. Assigned to J. Bobst and Son S. A. [Cl. 100-299.] Improved means are provided for effecting the lateral withdrawal of plates and the like from the press.

Linsk, Jack, and Todd, Robert W. Ammonium nitrate propellant. U. S. patent 2,936,225. Filed March 21, 1956. 8 claims. Assigned to Standard Oil Co. [Cl. 52-.5.] Cellulose acetate and cellulose acetate butyrate are used.

Mestre, Luis. Collating machine. U. S. patent 2,936,168. Filed May 31, 1957. 39 claims. [Cl. 270-58.]

Mischke, Edward M. Box making machine. U. S. patent 2,935,832. Filed Feb. 3, 1958. 3 claims. [Cl. 53-374.] A carton of the wallet type is formed and locked about a product such as handkerchiefs or the like.

Munkachy, Elmer E. Can holder. U. S. patent 2,936,068. Filed Aug. 29, 1957. 2 claims. [Cl. 206-46.] A collapsible handled paperboard device is provided as a holder for a can of beverage during its consumption.

Nelson, Alfred M., Stern, Hans M., and Wiener, Jerome B. Card processing apparatus. U. S. patent 2,936,169. Filed Feb. 4, 1957. 27 claims. Assigned to Magnavox Co. [Cl. 271-5.] In a data card processing system, means are provided to shift the position of a card with respect to other cards being processed.

O'Neil, John G. Method and machine for making a container. U. S. patent 2,935,919. Filed Nov. 8, 1956. 8 claims. Assigned to Rapinwax Paper Co. [Cl. 93-82.] The machine provided forms a paperboard sheet into cylindrical form with overlapping joint and seals the joint.

O'Sullivan, Denis J. Methods of copy reproduction. U. S. patent 2,935,938. Filed April 17, 1956. 3 claims. Assigned 50% to Eugene Lefebure. [Cl. 101-149.4.] A transfer sheet is provided for use in hectographic duplicating.

Otis, Carl W. Knockdown stand for holding bottles. U. S. patent 2,936,144. Filed April 27, 1955. 3 claims. [Cl. 248-150.] Hardboard elements are assembled to form a structure for supporting a bottle or the like.

Pluckebaum, Jerome J. Loose-leaf retaining device. U. S. patent 2,935,986. Filed Oct. 20, 1955. (Divided; original filed Nov. 3, 1954.) 1 claim. Assigned to The Montgomery Printing Co. [Cl. 129-23.] A simple one-piece sheet-retaining device is provided in a loose-leaf binder.

Randles, Arthur E., Jr. Carton forming machine. U. S. patent 2,935,917. Filed April 18, 1958. 8 claims. Assigned 50% to Fred E. Helmick. [Cl. 93-37.] A machine for erecting paperboard egg cartons is designed to prevent jamming, to reduce floor space requirements, and to provide adjustability of speed.

Reik, Ella H. Heater for canned food. U. S. patent 2,935,983. Filed March 15, 1957. (Divided; original filed May 17, 1954.) 7 claims. [Cl. 126-263.] An assembly of foil and paper contains a chemical which is rendered exothermic upon wetting and is designed for heating a can of army rations in the field.

Rendall, Warren C. Convertible container and method of packing and shipping same. U. S. patent 2,936,239. Filed June 21, 1954. 7 claims. Assigned to Crown Zellerbach Corp. [Cl. 99-171.] Body and cover sections of a produce-shipping container each convert to form separate and smaller containers.

Sillcox, Edward L., and Witt, Harry S. Battery separator and method of making same. U. S. patent 2,936,328. Filed Feb. 26, 1958. 7 claims. Assigned to U. S. Rubber Co. [Cl. 136-145.] Ribs of vinyl resin are attached to a flat sheet of felted cellulosic fibers.

Stevenson, Allan B. Method and apparatus for depositing cut lengths of filament transversely of a moving web. U. S. patent 2,936,022. Filed Oct. 4, 1954. 13 claims. Assigned to American Sisalkraft Corp. [Cl. 154-1.7.]

Storch, Otto P. Knock-down parallelogrammic display device. U. S. patent 2,936,079. Filed Aug. 7, 1959. 10 claims. Assigned to Einson-Freeman Co., Inc. [Cl. 211-177.] A collapsible display stand is setup from paperboard elements and held in erected condition by the tension of an elastic band.

Townsend, Elmer D., Jr., and Hoffman, Richard A. Display mount sheet for greeting cards. U. S. patent 2,935,807. Filed Sept. 3, 1957. 3 claims. Assigned to Gibson Art Co. [Cl. 40-158.]

Walker, William E. Machines for stripping unwanted material from cut blanks of cardboard and like material. U. S. patent 2,935,916. Filed July 12, 1957. 6 claims. [Cl. 93-36.]

Woelky, Conrad G. Foldable stand or pedestal. U. S. patent 2,936,145. Filed July 7, 1955. 1 claim. Assigned to Buckley Dunton & Co., Inc. [Cl. 248-174.] A store window display stand is setup from paperboard elements.

Woodring, Clarence W., and Knepper, Joseph E. Stencil with magnetic holding means. U. S. patent 2,935,936. Filed July 17, 1956. 5 claims. [Cl. 101-128.1.]

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Allen, Lloyd G., and McMillan, Donald A. Pleated filter and mechanism for forming same. U. S. patent 2,936,855. Filed Oct. 23, 1957. 2 claims. Assigned to General Motors Corp. [Cl. 183-71.] The pleated filter material is provided with mechanical deformations which give the correct spacing to the pleats.

Bartell, Charles, Weidner, Charles L., and Smith, Richard M. Pressure-sensitive adhesive tape. U. S. patent 2,937,109. Filed May 7, 1956. 3 claims. Assigned to Johnson & Johnson. [Cl. 117-122.] The paper backing is impregnated with a chloroprene elastomer and an aminoacetic acid.

Berghgracht, Marius. Fluid tight packages. U. S. patent 2,936,940. Filed Oct. 26, 1956. 1 claim. [Cl. 229-16.] A package for liquids or powders is formed of heat-sealable paper or plastic.

Carpenter, Joseph E., and Kolodny, Edwin R. Dialkylpolyaminopolyalkalene amides as asphalt antistripping agents. U. S. patent 2,937,106. Filed Sept. 11, 1957. 6 claims. Assigned to American Cyanamid Co. [Cl. 106-273.] The amides used are derivatives of tall oil fatty acids.

Cazemier, Frits, and Moen, Willem H. G. Method of pasting by machine. U. S. patent 2,937,105. Filed May 24, 1956. 3 claims. Assigned to North American Philips Co., Inc. [Cl. 106-193.] A starch adhesive is provided for making corrugated paper.

Columbus, John, Pesch, Herman, and Wilcox, Isaac L. Container top printing mechanism. U. S. patent 2,936,702. Filed Feb. 10, 1958. 6 claims. Assigned to Sealright-Oswego Falls Corp. [Cl. 101-44.]

Cox, Normal L. Viscose process. U. S. patent 2,937,070. Filed Aug. 2, 1955. 10 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 18-54.] High-tenacity rayon filaments are prepared by conducting spinning and stretching operations under specified conditions.

Cummings, Thomas N., Peterson, Benjamin R., Jr., and Shiu, Thomas B. Packaging machine for flowable material. U. S. patent 2,936,798. Filed Sept. 10, 1953. 3 claims. Assigned to CPS Mfg. Co. [Cl. 141-88.] A machine for filling erected containers with ice cream is provided with feeding means for the containers.

Downs, Samuel M. Container display kit. U. S. patent 2,936,879. Filed July 16, 1954. 1 claim. Assigned to Owens-Illinois Glass Co. [Cl. 206-45.19.] A hinged cover-container is provided with an internal supporting panel which has openings for holding glass vials in a display position.

Fay, Rudolph J. Sandwich assembly and packaging machine. U. S. patent 2,936,557. Filed July 21, 1958. 24 claims. Assigned to Peters Machinery Co. [Cl. 53-159.] Cookies of the sandwich type are formed, grouped, and bagged.

Forsythe, Alan K. Tall oil fatty acid containing linoleum cement. U. S. patent 2,937,103. Filed April 29, 1957. 7 claims. Assigned to Armstrong Cork Co. [Cl. 106-123.]

Fulton, James F. Surgical glove package. U. S. patent 2,936,881. Filed Oct. 8, 1958. 2 claims. Assigned to The Seamless Rubber Co. [Cl. 206-46.] The container used is a walletlike paper folder.

Galley, Hollis T., and Spelbrink, Frank B. Mechanism for wrapping roll paper. U. S. patent 2,936,559. Filed Feb. 26, 1958. 9 claims. Assigned to Eastman Kodak Co. [Cl. 53-211.]

Gard, George E. Breaker device. U. S. patent 2,936,909. Filed Sept. 23, 1957. 1 claim. Assigned to Armstrong Cork Co. [Cl. 214-8.5.] An apparatus for holding acoustical tiles in a stack during a portion of their drying is provided with means to prevent the tiles from sticking to each other.

Gentry, Hermond G. Apparatus for packaging articles. U. S. patent 2,936,560. Filed June 15, 1956. 7 claims. Assigned to Mead Pkg., Inc. [Cl. 53-219.] A paperboard blank is wrapped and secured about an assembled group of cans to form a unitized pack.

Guyer, Reynolds. Dispensing carton. U. S. patent 2,936,937. Filed March 18, 1957. 7 claims. [Cl. 225-48.] An elongated dispensing carton is provided for rolls of waxed paper or the like.

Harpman, Sol. Send-and-return envelopes. U. S. patent 2,936,946. Filed Nov. 16, 1953. 2 claims. [Cl. 229-73.]

Heller, Hugo R. Bag opener or tearing device. U. S. patent 2.936,938. Filed Sept. 14, 1955. 1 claim. [Cl. 225-82.]

Hindle, Thomas, and Race, Edward. Papermakers' drier felt. U. S. patent 2,936,796. Filed July 3, 1956. 16 claims. Assigned to Scapa Dryers Ltd. [Cl. 139-426.] In a multi-ply felt, the paper-contacting ply is made of dacron, the other outer ply of cotton, and an intermediate ply of asbestos.

Iverson, Robert J. Apparatus for washing film. U. S. patent 2,936,468. Filed April 18, 1956. 8 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 15-93.]

Jauss, Albert. Apparatus for making ring closures. U. S.

patent 2,936,485. Filed Dec. 24, 1956. 7 claims. Assigned to Bohm & Co. [Cl. 18-19.] Plastic comb rolls are provided for use in binding paper sheets.

Keil, Henry P. Copy sheet receiving tray for duplicating machines. U. S. patent 2,937,021. Filed March 24, 1958. 3 claims. Assigned to Fixture Hardware Corp. [Cl. 271-86.] Sliding contact between the sheets in the tray and resultant smearing are prevented.

Kleist, Dale. Method and apparatus for the attenuation of heat softenable materials into fibers. U. S. patent 2,936,480. Filed May 18, 1956. 9 claims. Assigned to Owens-Corning Fiberglas Corp. [Cl. 18-2.5.]

Kohlhaas, Frank A. Positioning and retaining member. U. S. patent 2,936,880. Filed Oct. 6, 1958. 2 claims. Assigned to Crown Zellerbach Corp. [Cl. 206-46.] An interior packing member is provided for spacing a water heater from the walls of its shipping container.

Kukowski, John L., Kovacs, Julius P., and Pierfederici, Alfred J. Filter unit. U. S. patent 2,936,891. Filed March 26, 1957. 3 claims. Assigned to Purolator Prods. Inc. [Cl. 210-131.] A molded fiber-resin oil filter is designed to eliminate conventional end caps.

Layden, Paul W. Sheet registering system for printing presses and the like. U. S. patent 2,937,020. Filed April 6, 1956. 9 claims. [Cl. 271-58.]

Lau, Erwin M. Bag filling machine. U. S. patent 2,936,994. Filed Sept. 10, 1956. 17 claims. Assigned to Black Prods. Co. [Cl. 249-60.] Means are provided to remove accumulations of the powdered material being bagged from critical surfaces of the bagging machine.

Levkoff, David. Cartons. U. S. patents 2,936,943. Filed Nov. 15, 1957. 3 claims. Assigned 25% to Evelyn S. Levkoff, 25% to Henry S. Levkoff, and 25% to Edith L. Sennet. [Cl. 229-28.] Various structural improvements are made in a paperboard egg carton.

Lewis, Charles. Cartons. U. S. patent 2,936,941. Filed Oct. 8, 1957. 7 claims. Assigned to Celanese Corp. of America. [Cl. 229-23.] A shipping container for yarn cones adjusts to the height of the cones.

Lundquist, Oliver. Box structures. U. S. patent 2,936,939. Filed Oct. 19, 1956. 5 claims. [Cl. 229-8.] An octahedral box is setup by existing machinery from a blank cut from a web without excessive waste.

McKay, Arthur F., and Podesva, Ctirad. Stabilized phenol-formaldehyde resins. U. S. patant 2,937,159. Filed Dec. 23, 1957. 4 claims. Assigned to Monsanto Can. Ltd. [Cl. 260-59.] The resins are of use in wood-particle board and the like.

McLearn, Herbert McK. Container filling and weighing apparatus. U. S. patent 2,936,993. Filed Feb. 29, 1956. 14 claims. Assigned to American Machinery Corp. [Cl. 249-59.]

Moore, George A. Telescopic self-sealing containers. U. S. patent 2,936,944. Filed April 11, 1958. 8 claims. [Cl. 229-34.] A package comprises a paperboard tray in a plastic sleeve, with means for sealing the two elements.

Morrison, Albert R. Apparatus for forming fibrous glass. U. S. patent 2,936,479. Filed April 23, 1956. 5 claims. Assigned to Owens-Corning Fiberglas Corp. [Cl. 18-2.5.]

Naffin, Alfred. Shear for forming rounded corners on rectangular cards, etc. U. S. patent 2,926,665. Filed July 26, 1957. 2 claims. [Cl. 83-583.]

Nevins, Warren. Display cartons. U. S. patent 2,936,942. Filed Aug. 28, 1957. 5 claims. [Cl. 229-28.] Eggs are supported in a paperboard structure which leaves much of the egg exposed to view, and the assembly is overwrapped in film.

Peters, William H. Holder for milk cartons. U. S. patent 2,936,927. Filed Aug. 5, 1957. 1 claim. [Cl. 220-85.] A collapsible handled paperboard holder is provided for supporting a paperboard milk carton during use.

Rose, Bertram L. Card feeding apparatus. U. S. patent 2,937,019. Filed Feb. 18, 1957. 7 claims. Assigned to International Computers and Tabulators Ltd. [Cl. 271-44.] An apparatus for feeding cards to a business machine is designed to prevent damaging the cards.

Saffir, Jacob A. Cigarettes. U. S. patent 2,936,763. Filed Nov. 8, 1957. 1 claim. [Cl. 131-15.] A vent is provided in the wrapper so that the smoke may be mixed with air.

Sano, Tomitaro T. Sheet material dispenser. U. S. patent 2,936,936. Filed May 29, 1959. 3 claims. [Cl. 225-43.] Various improvements are made in a container and dispensing apparatus for a roll of paper.

Schulz, Alfred E. A. Labeling machine for workpieces in upright position. U. S. patent 2,936,921. Filed Dec. 17, 1957. 5 claims. Assigned to Johann Weiss Maschinenfabrik und Apparatebau G.m.b.H. [Cl. 216-55.]

Seven, Raymond P., and Miyashiro, James J. Composite photosensitive plate, and method of making printing plate therefrom. U. S. patent 2,937,085. Filed Jan. 11, 1954. 5 claims. Assigned to Ditto, Inc. [Cl. 96-33.] A paperbase offset printing plate is prepared.

Snyder, Francis H. Process for forming resins from phenols and hydropyrolysis products of lignocellulose. U. S. patent 2,937,158. Filed June 28, 1956. 8 claims. Assigned to Francis H. Snyder and Associates, Inc. [Cl. 260-56.] The resins may be used for paper-impregnating and laminating.

Van Tuyl, Sidney. Cigarette filter. U. S. patent 2,936,764. Filed June 6, 1956. 5 claims. [Cl. 131-208.] The filter is made of strips of creased paper.

Walles, Wilhelm E. Method for treating polyethylene and treated polyethylene articles thereby obtained. U. S. patent 2,937,066. Filed Nov. 23, 1955. 12 claims. Assigned to The Dow Chemical Co. [Cl. 8-4.] Polyethylene surfaces are treated with a sulfonating reagent to improve dyeability and reduce static accumulations.

Whitman, Harlan M. Banking envelope. U. S. patent 2,936,945. Filed Oct. 13, 1958. 4 claims. Assigned to Curtis 1000, Inc. [Cl. 229-72.]

Williams, Philip M. Molded pulp packing tray. U. S. patent 2,936,922. Filed March 7, 1958. 18 claims. Assigned to Keyes Fibre Co. [Cl. 217-26.5.]

Zimmerli, Kurt. Removable roll means for calender. U. S. patent 2,936,699. Filed March 25, 1959. 4 claims. Assigned to B. F. Perkins & Sons, Inc. [Cl. 100-155.]

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Ackley, Edward. Apparatus for fastening cartons. U. S. patent 2,937,486. Filed Jan. 13, 1959. 3 claims. Assigned to Julian B. Slevin Co., Inc. [Cl. 53-374.] Means are provided to interlock the end closure flaps of filled can carrier cartons.

Adams, Marion F. Fibreboard fork lift containers. U. S. patent 2,937,799. Filed Jan. 31, 1955. 2 claims. Assigned to Inland Container Corp. [Cl. 229-14.] The fork truck tines enter holes just beneath the reinforced top of the container.

Bowen, Richard Le Baron, Jr. Constant web tension unwinding mechanism. U. S. patent 2,937,819. Filed Sept. 30, 1955. 13 claims. [Cl. 242-75.5.]

Buttery, Kenneth T., and Vander Lugt, Thomas, Jr. Display carton. U. S. patent 2,937,743. Filed Jan. 31, 1958. 8 claims. Assigned to KVP Sutherland Paper Co. [Cl. 206-45.14.] An elongated windowed carton is provided for packing a dispensing tube.

Clement, Ernest C. Box making apparatus. U. S. patent 2,937,536. Filed Jan. 3, 1956. 6 claims. [Cl. 74-26.] Improvements are made in a machine having different sized plungers cooperating with an adjustable die to make a wide range of box sizes.

Dazzi, Joachim. Olefinically unsaturated adduct and method of preparing same. U. S. patent 2,938,044. Filed Oct. 14, 1955. 4 claims. Assigned to Monsanto Chemical Co. [Cl. 260-404.8.] A tall oil derivative is prepared.

Didde, Carl W., and Glaser, Donald A. Sheet supporting and handling apparatus. U. S. patent 2,937,868. Filed May 5, 1958. (Divided; original filed Jan. 24, 1955.) 3 claims. [Cl. 271-30.] Paper sheets are assembled into pad form and adhesively interconnected.

Dorfmann, Oskar. Box blank folding machine. U. S. patent 2,937,578. Filed Oct. 7, 1957. 19 claims. Assigned to Federal Carton Corp. [Cl. 93-49.] The boxes are of a flat interlocked type with hinged fully telescoping cover.

Fink, Raymond E. Carriers for a plurality of articles. U. S. pat. 2,937,747. Filed Sept. 22, 1958. 2 claims. Assigned to The New Haven Board and Carton Co. [Cl. 206-80.] A number of powder-containing pouches are mounted on a diecut handled card.

Green, Emil, and Schlanger, Samuel. Tag machines. U. S. patent 2,937,579. Filed March 23, 1959. 10 claims. [Cl. 93-91.] A string loop is applied to a paper tag.

Loomer, Joseph T. Coating process. U. S. patent 2,937,955. Filed Dec. 24, 1957. 4 claims. Assigned to Continental Can Co., Inc. [Cl. 117-38.] Paper is coated with a first rough coat, then with a second coat to fill the pits in the first.

Marshall, Edward C. Tag with fastening wire. U. S. patent 2,937,464. Filed Jan. 11, 1957. 15 claims. Assigned to American Tag Co. [Cl. 40-2.] Paperboard tags with fastening wires are supplied in the form of a rolled strip, with the wires affixed to avoid entanglement.

Michiel, Joseph. Dispensing device for merchandise. U. S. patent 2,937,742. Filed April 7, 1958. 4 claims. [Cl. 206-44.12.] Articles in the traylike dispenser are urged to the front by a rubber-band powered follower as the articles are removed for sale.

Muench, Carl G. Apparatus for applying mortar simulating lines on insulating siding. U. S. patent 2,937,614. Filed June 16, 1955. (Divided; original filed Jan. 17, 1952.) 3 claims. Assigned to The Celotex Corp. [Cl. 118-301.]

Muller, Henry W. Paper crinkle cup separating device. U. S. patent 2,937,786. Filed May 16, 1957. 2 claims. Assigned to Muller Paper Goods Co., Inc. [Cl. 221-211.] Paper crinkle cups are separated one at a time from a nested stack and forwarded for filling or the like.

Nefflen, Karl F. Plastic film abrasive sheet. U. S. patent 2,937,934. Filed June 29, 1951. 6 claims. Assigned to U. S. Secretary of Commerce. [Cl. 51-293.] The sheet comprises paper to which is adhered a plastic film in which is embedded abrasive material.

Netherwood, Paul H. Electrical capacitors. U. S. patent 2,938,153. Filed May 14, 1956. 12 claims. Assigned to Sprague Electric Co. [Cl. 317-258.] The capacitor comprises a winding of paper on which is disposed a metallized film, such as a film of a cross-linked cellulose ester.

Nugent, Henry E. Visual display and method of making same. U. S. patent 2,937,931. Filed Sept. 17, 1958. 1 claim. [Cl. 41-34.] A display to be assembled by children comprises a paperboard backing to which are adhered a number of different colored beans.

Olle, Earl W. Ash tray attachable to cigarette package. U. S. patent 2,937,741. Filed June 10,1959. 4 claims. [Cl. 206-38.]

Olson, Frederick F. Container. U. S. patent 2,937,744. Filed Oct. 5, 1959. 2 claims. Assigned to B. F. Goodrich Co. [Cl. 206-45.33.] A display container comprises an open-top box within a plastic film bag.

Reiner, George. Dispensing carton for paper cups. U. S. patent 2,937,784. Filed July 25, 1957. 5 claims. [Cl. 221-63.]

Reustle, Frank A. Asphalt roof laying machine. U. S. patent 2,937,779. Filed March 28, 1958. 9 claims. [Cl. 216-20.]

Root, Frank B. Rosin modified poly(alkylene fumarate). U. S. patent 2,938,006. Filed May 15, 1959. 7 claims. Assigned to U. S. Rubber Co. [Cl. 260-26.] A synthetic resin is formed; the rosin used may be tall oil rosin.

Rupp, Fritz. Intermediate stacking device. U. S. patent 2,937,869. Filed Feb. 25, 1959. 4 claims. Assigned to Maschinenfabrik Augsburg-Nurnberg, A.G. [Cl. 271-86.] A printing press is provided with means to move the auxiliary sheet-receiving table into position during the interval between delivery of two sheets.

Tabb, James W. Holder for clothing and like. U. S. patent 2,937,758. Filed Aug. 10, 1956. 1 claim. [Cl. 211-1.] A panelboard backing is provided with a number of clips on one face for holding small items of clothing, and with a hanger hook at the top.

Toniolo, Luciano, and Garbin, Giralamo. Pipemaking machines. U. S. patent 2,937,701. Filed May 14, 1956. 2 claims. [Cl. 162-284.] A machine for winding asbestos-cement sheet onto mandrels is provided with automatic means for feeding and withdrawing the mandrels.

Wall, Howard M. Packaging machine for flat articles. U. S. patent 2,937,485. Filed Oct. 5, 1953. 25 claims. [Cl. 53-187.] A stack of several hardboard sheets or the like is inserted into a paperbag and the bag is closed and sealed.

Walton, Charles W., and Buttery, Kenneth T. Packaging device for food products and the like. U. S. patent 2,937,800. Filed May 28, 1958. 5 claims. Assigned to KVP Sutherland Paper Co. [Cl. 229-87.] A board blank is folded about a group of shingled bacon strips and the assembly is overwrapped in film.

Ward, Robert E., Jr., and Ward, Joan M. Strip film and viewer. U. S. patent 2,937,566. Filed May 13, 1957. 1 claim. [Cl. 88-19.] A device for viewing a film strip is formed of paperboard.

Wiman, Karl O. Device for automatically bundling material. U. S. patent 2,937,484. Filed Feb. 5, 1957. 10 claims. Assigned to Kopparfors Aktiebolag. [Cl. 53-135.] A press for compressing a stack of sheets of pulp is provided with means for bundling each compressed stack with wire.

Winston, Rodney W. Sheet filing equipment. U. S. patent 2,937,646. Filed Sept. 26, 1956. 3 claims. Assigned to Moore Business Forms, Inc. [Cl. 129-16.] A filing system, including business forms and a file folder, is provided in which the sheets are held in overlapping relation with marginal portions of the sheets registering with the other sheets.

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Allan, Charles R. Machine and method for producing prefabricated material of cellular construction. U. S. patent 2,938,567. Filed May 15, 1956. 9 claims. [Cl. 154-30.] Paper is subjected to a series of reverse bending operations and the bends secured in place to form a cellular product of use as a core in building boards.

Beachler, Edward D. Fourdrinier wire stringing method and apparatus. U. S. patent 2,938,581. Filed May 22, 1956. 14 claims. Assigned to Beloit Iron Works. [Cl. 162-273.]

Bertram, John C. Basket and handle combination. U. S. patent 2,938,656. Filed Feb. 3, 1958. 8 claims. Assigned to Bertram Wire Prods., Inc. [Cl. 229-52.] The strap handle of a paperboard basket telescopes closed when not in use.

Boyd, Millard C. Wood chip level control. U. S. patent 2,938,639. Filed Nov. 27, 1957. 7 claims. Assigned to Allied Chemical Corp. [Cl. 214-17.] A digester is provided with means for delivering wood chips at a constant rate.

Browning, Herbert M., and Hammock, Branch R. Carton for wound yarn. U. S. patent 2,938,625. Filed April 16, 1959. 5 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 206-65.] A carton is provided with interior packing members by which tubes of wound yarn are supported for shipment.

Buckingham, William D., Ridge, Guy H., Root, Lawrence D., and Turner, Frank T. Copy sheet storage and feed mechanism. U. S. patent 2,938,721. Filed March 15, 1957. 10 claims. Assigned to The Western Union Telegraph Co. [Cl. 271-41.] A telegraphic facsimile transmitting apparatus is provided with means for storing and feeding copy sheets through the transmitter.

Chaplin, Merle P. Apparatus for making molded pulp articles. U. S. patent 2,938,582. Filed Sept. 29, 1953. 25 claims. Assigned to Diamond National Corp. [Cl. 162-392.]

Cock, William H. Machine for and method of corrugating paper. U. S. patent 2,938,568. Filed Nov. 27, 1956. 5 claims. Assigned to Arkell Safety Bag Co. [Cl. 154-30.]

de la Rosa, Joaquin, Sr., and de la Roza, Joaquin, Jr. Continuous cellulose pulp digester. U. S. patent 2,938,580. Filed April 2, 1953. de la Roza, Jr.'s interest assigned to de la Roza, Sr. [Cl. 162-244.]

Gray, Kenneth R., Steinberg, John C., and Crosby, Hartzell L. Alkali bark derivative. U. S. patent 2,938,893. Filed Dec. 28, 1955. 7 claims. Assigned to Rayonier Inc. [Cl. 260-124.] Douglas-fir bark or the like is digested to provide a derivative of use in drilling muds or the like.

Helm, Jack D. Paper bags having airtight areas to facilitate automatic bag feeding. U. S. patent 2,938,657. Filed Oct. 28, 1957. 3 claims. [Cl. 229-55.]

Hillman, James G. E. Apparatus for collecting cigarettes in receptacles. U. S. patent 2,938,317. Filed June 23, 1958. 6 claims. Assigned to Molins Machine Co. Ltd. [Cl. 53-148.] The receptacle groups cigarettes for insertion into a packaging container and is designed to provide extra space for the tipped ends of cigarettes.

Hopkins, Frank L. Method of and apparatus for evacuating air from bag body at time of filling. U. S. patent 2,938,314. Filed Oct. 28, 1957. 5 claims. Assigned to Bemis Bro. Bag Co. [Cl. 53-22.]

Horn, Heinz. Electrical cable for heavy currents. U. S. patent 2,938,943. Filed Nov. 26, 1954. 4 claims. Assigned to Felton & Guileaume Carlswerk A.G. [Cl. 174-102.] The insulation used includes oil-impregnated paper and carbon black paper.

Justus, Edgar J. Motor control for paper machine drive arrangement. U. S. patent 2,939,062. Filed May 24, 1956. 5 claims. Assigned to Beloit Iron Works. [Cl. 318-44.]

Lesch, Hans. Wrapping machines. U. S. patent 2,938,320. Filed June 17, 1958. 28 claims. Assigned to Otto Hänsel Junior G.m.b.H. [Cl. 53-234.] Articles such as pieces of candy are wrapped.

Malcolm, Robert J. Printed circuit panel. U. S. patent 2,938,939. Filed Sept. 19, 1956. (Dividied; original filed May 31, 1956.) 1 claim. [Cl. 174-68.5.] Necessary holes are formed in the resin-impregnated paper laminate used as the base board during the molding of the board.

Marpillero, Paolo. Bleaching of cellulosic pulp. U. S. patent 2,938,826. Filed Sept. 2, 1958. 3 claims. Assigned to Societe pour l'Amelioration et le Development des Procedes Industriels (SADEPI). [Cl. 162-87.] The pulp is contacted with sodium chlorate in the presence of a vanadium catalyst.

Mittag, Walter P. Web control device. U. S. patent 2,938,-720. Filed July 1, 1957. 16 claims. Assigned to J. M. Voith G.m.b.H. [Cl. 271-2.6.] A paper machine is provided with a guide roll and control device therefor.

Nelson, John D. High bond strength laminate product. U. S. patent 2,938,822. Filed May 26, 1955. 6 claims. Assigned to General Electric Co. [Cl. 154-137.] The laminate is for use in upholstering and includes a mat of wood pulp fibers.

Nystrand, Ernst D. Apparatus for handling cylindrical objects. U. S. patent 2,938,319. Filed Nov. 4, 1957. 4 claims. Assigned to Paper Converting Machine Co., Inc. [Cl. 53-214.] Means are provided to handle and convey a roll of toilet tissue or the like as it is being wrapped or banded.

Paulson, Harold E. Side guide register for sheet feeders. U. S. patent 2,938,723. Filed July 17, 1958. 14 claims. (Cl. 271-49.]

Richards, Russell N. Carton cutter. U. S. patent 2,938,264. Filed Jan. 2, 1959. 3 claims. [Cl. 30-2.] A razor blade is replaceably mounted in a holder and the device used to open cartons.

Richter, Frederick H. Method of resisting digester corrosion. U. S. patent 2,938,825. Filed Jan. 30, 1953. 5 claims. Assigned to The Babcock & Wilcox Co. [Cl. 162-48.]

Richter, Johan C. F. C. Digestion apparatus and method. U. S. patent 2,938,824. Filed Jan. 22, 1958. 9 claims. As-

signed to Aktiebolaget Kamyr. [Cl. 162-42.] Means are provided to dilute pulp being discharged from a continuous digester with spent liquor separated from the discharged pulp.

Standal, George M. Knife mounting for planer chippers. U. S. patent 2,938,553. Filed May 15, 1959. 10 claims. [Cl. 144-224.]

Thomas, John W. Package fabricating machines. U. S. patent 2,938,318. Filed April 25, 1957. 20 claims. Assigned to Aspro-Nicholas Ltd. [Cl. 53-180.] A machine which seals two webs together to form packets is adjustable to make different sized packets without requiring substitution of machine parts.

Tien, Jack M. Thermotransfer duplicating process. U. S. patent 2,939,009. Filed Feb. 1, 1956. 22 claims. [Cl. 250-65.] Heat-sensitive transfer and copy sheets are described.

Van Bochove, Cornelis, and Hueck, Hendrik J. Process for making cellulose materials rotproof. U. S. patent 2,938,815. Filed June 30, 1958. 5 claims. Assigned to Nederlandse Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek ten behoeve van Nijverheid, Handel en Verkeer. [Cl. 117-138.5.] The agents used are chloracetamide and formaldehyde.

Voullaire, Izak J. Method and apparatus for packing fruit. U. S. patent 2,938,315. Filed Jan. 27, 1958. 19 claims. [Cl. 53-35.] The apparatus provided packs fruit into a shipping container so as to form rows and layers of a certain prescribed pattern.

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Anness, Russell W. Carton forming and loading apparatus. U. S. patent 2,939,258. Filed June 16, 1958. 16 claims. Assigned to Lengsfield Brothers Inc. [Cl. 53-183.] A paperboard sleevelike carton for unitizing two cans is formed, filled, and sealed by the apparatus provided.

Bartelt, Harold L. Mechanism for adding tape to tea bag. U. S. patent 2,939,257. Filed March 26, 1958. 4 claims. Assigned to Bartelt Eng. Co., Inc. [Cl. 53-134.]

Bjarnow, Fred B., Cichelli, Mario T., and Hamilton, Alan G. Vapor treatment of a moving web. U. S. patent 2,939, 760. Filed Oct. 26, 1955. 3 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 8-149.2.] The moist paper web is bleached on a paper machine by contacting it with hydrogen peroxide vapor.

Briggs, Glenford E. Cigarette packaging. U. S. patent 2,939,600. Filed April 4, 1958. 3 claims. [Cl. 216-29.] The apparatus provided applies strips of pressure-sensitive tape to opposite sides of a group of five cigarette packs.

Calhoun, Samuel E. Envelope flap opening device. U. S. patent 2,939,261. Filed Dec. 5, 1958. 8 claims. Assigned to Pitney-Bowes, Inc. [Cl. 53-381.] The flaps of envelopes in a stack are opened to receive inserts.

Cannan, John J. Paper sampler. U. S. patent 2,939,210. Filed Sept. 14, 1954. 6 claims. [Cl. 30-124.] An apparatus is provided for cutting a sample from the moving paper web on the paper machine.

Cunnien, Arthur L. Combination package. U. S. patent 2,939,577. Filed March 12, 1959. 6 claims. Assigned to The Gillette Co. [Cl. 206-47.] A paperboard band fits about a bottle or the like and has means to hold an associated item of merchandise such as a brush.

D'Ippolito, Joseph M. Partitioned folding containers. U. S. patent 2,939,622. Filed Oct. 4, 1956. 2 claims. [Cl. 229-39.] A jar of cosmetic preparation or the like is supported by integral panels within a display carton.

Fleischmann, Lester K. Carbon paper pack. U. S. patent 2,939,726. Filed July 8, 1958. 4 claims. [Cl. 282-19.] The pack is for use in manifolding.

Flicker, Max. Folded one-piece carton. U. S. patent 2,939,576. Filed April 5, 1957. 1 claim. [Cl. 206-46.] A flat carton having multi-ply side and end walls is provided for packing furniture items.

Grant, Jesse R. Cartons for eggs. U. S. patent 2,939,602. Filed Oct. 30, 1956. 20 claims. [Cl. 217-26.5.] Molded pulp egg flats and cartons are described.

Hasler, Winfields. Closure construction. U. S. patent 2,939,-617. Filed May 20, 1957. 1 claim. Assigned to Morton Salt Co. [Cl. 222-556.] A closure element is provided for a sifter device located in the top panel of a cylindrical paperboard salt container.

Haver, Fritz. Method of treating filling material and an apparatus for carrying out this method. U. S. patent 2,939,494. Filed July 30, 1954. 30 claims. [Cl. 141-1.] A machine for filling bags with cement is provided with means to compress the cement prior to loading into the bags to remove air.

Haywood, Russell I. Cutting machines with means for automatically disabling the cutting drive and reducing the pressure of the clamp drive during replacement of the blade. U. S. patent 2,939,357. Filed Dec. 19, 1957. 6 claims. Assigned to Harris-Intertype Corp. [Cl. 83-380.]

Heckler, Samuel. Wrapping device. U. S. patent 2,939,259. Filed May 6, 1958. 1 claim. Assigned to United States Rubber Co. [Cl. 53-259.] A hollow frame is provided to assist in packing large bulky items in a bag by rolling the bag down over the outside of the article.

LeTourneau, Robert G. Log handling machine. U. S. patent 2,939,596. Filed Aug. 5, 1957. 3 claims. [Cl. 214-654.] An improved lift carriage mechanism is provided in a fork-lift log-handling machine.

Mittleman, Albert. Container. U. S. patent 2,939,621. Filed Jan. 27, 1959. 4 claims. Assigned to Buchanan Electrical Prods. Corp. [Cl. 229-17.] An improved hinged cover is provided in a small box for packing small items such as washers, nuts, and the like.

Nigrelli, Biagio J., Standley, Wendell E., and Wittmann, Richard B. Case loading mechanism and method of loading cases. U. S. patent 2,939,256. Filed April 25, 1957. 20 claims. Assigned to Ralph W. Johns, Biagio J. Nigrelli, and Robert R. Johns. [Cl. 53-26.] Cans are assembled into a group and the group is cased.

Ogle, George L., Betts, Timon R., and Turner, Gerald W. Machine for closing container flaps. U. S. patent 2,939,260. Filed April 28, 1958. Assigned to Container Corp. of America. [Cl. 53-374.] The machine closes the bottom flaps of a shipping container holding a heavy article while the filled container is supported from below.

Riccardi, John. Carton divider. U. S. patent 2,939,623. Filed March 28, 1955. 1 claim. [Cl. 229-42.] A bottle case partitioning member is designed so that a number of smaller sample bottles may be nested in the upper part of the partitioning device.

Schluter, Harry C. Automatic labeling machine. U. S. patent 2,939,599. Filed April 29, 1957. 13 claims. [Cl. 216-9.]

Sevison, Luther E. Web severing apparatus with reciprocating feeding and blank delivering means. U. S. patent 2,939,355. Filed July 25, 1955. (Divided; original filed Jan. 10, 1952.) 1 claim. Assigned to E. G. Staude Mfg. Co., Inc. [Cl. 83-222.] Box blanks are formed from a web of thermoplastic material.

Snyder, Leonard W. Container with locking closure. U. S. patent 2,939,625. Filed Sept. 20, 1957. 3 claims. Assigned to Container Corp. of America. [Cl. 229-45.] A split cover shipping container is provided with end wall constructions which support the ends of the covers and which provide locking means for the covers.

Stein, Elmer L. Display mounted by a bow from a post. U. S. patent 2,939,237. Filed Aug. 25, 1958. 7 claims. Assigned to Eye-Beam Displays, Inc. [Cl. 40-311.] A display panel is mounted on the upper end of a paperboard tube and the lower end of the tube is supported about a bottle neck.

Stein, Elmer L. Sleeve and post advertising display. U. S. patent 2,939,236. Filed Feb. 13, 1958. 9 claims. Assigned to Eye-Beam Displays, Inc. [Cl. 40-311.] This is similar to U. S. patent 2,939,237 (June 7, 1960).

Stone, Wilfred H. Splicing control device. U. S. patent 2,939,646. Filed Jan. 14, 1957. 12 claims. Assigned to Meredith Publishing Co. [Cl. 242-58.2.] The transfer from an old roll to a new one in a web-fed printing press is carried out so that a minimum of waste is left on the old roll.

Strasser, Myron S. Frame for laundered shirts. U. S. patent 2,939,574. Filed Nov. 30, 1955. 2 claims. [Cl. 206-7.] The paperboard frame is provided with embossed ribs to improve the rigidity of the frame.

Svavar, Filip, Gustafsson, Rune, and Waern, Torsten. Method for drying or other treatment of a weblike material. U. S. patent 2,939,222. Filed June 23, 1954. 3 claims. Assigned to Aktiebolaget Svenska Flaktfabriken. [Cl. 34-18.] Improved efficiency is achieved in a process of drying a pulp web by training it about a drying cylinder while treating it with a drying medium.

Tracy, Glen M. Apparatus for perforating sheets. U. S. patent 2,939,356. Filed April 20, 1956. 10 claims. Assigned to Swanee Paper Corp. [Cl. 93-337.] The apparatus provided forms the perforations or slits transversely in a web of toilet tissue.

Whyte, Fred. Feeding and registration of sheets to printing and like machines. U. S. patent 2,939,703. Filed June 17, 1957. 2 claims. [Cl. 271-53.]

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Adams, Raymond C. Display stand base. U. S. patent 2,940,710. Filed Sept. 8, 1959. 5 claims. [Cl. 248-174.] The stand base is made of corrugated board.

Bennett, Alan, and Heywood, Derek W. Treatment of textiles. U. S. patent 2,940,863. Filed Dec. 15, 1958. 26 claims. Assigned to British Industrial Plastics Ltd. [Cl. 117-11.] Hydrophilic colloids such as carboxymethylcellulose are deposited in a textile or nonwoven fabric for bonding or stiffening purposes.

Bracey, Frederick J., Jr. Coupon attaching mechanism for bag forming machines. U. S. patent 2,940,233. Filed Oct. 18, 1957. 10 claims. Assigned to Package Machinery Co. [Cl. 53-137.]

Braun, Ralph V. Treatment of cellulosic pulps. U. S. patent

2,940,890. Filed June 25, 1956. 4 claims. Assigned to Kimberly-Clark Corp. [Cl. 162-111.] Soft facial tissues are prepared from normally unsuitable pulps by adding a fatty acid such as oleic acid to the pulp.

Brothers, William M. Production of plaster board. U. S. patent 2,940,505. Filed Oct. 12, 1953. 2 claims. Assigned to The British Plaster Board Ltd. [Cl. 154-1.2.]

Browne, Colin L. Crease-proofing cellulosic fabrics, the fabrics obtained and methods of making them. U. S. patent 2,940,817. Filed Jan. 29, 1957. 19 claims. Assigned to Rohm & Haas Co. [Cl. 8-116.2.]

Burt, Howard J., and Janesek, Louis F. Can unbagging and transferring apparatus and method. U. S. patent 2,940,624. Filed April 18, 1956. 8 claims. Assigned to Continental Can Co., Inc. [Cl. 214-152.]

Butler, Richard A., Jr. Splicing machine. U. S. patent 2,940,507. Filed Feb. 6, 1957. 1 claim. [Cl. 154-42.3.] A new supply roll is spliced to the tail of the web being drawn from an old roll and fed to a printing or other machine.

Carlsson, Sven, and Hellner, Gustaf. Loading and unloading apparatus for fiberboard or sheets of similar material. U. S. patent 2,940,614. Filed Sept. 12, 1958. 4 claims. Assigned to AB Svenska Flaktfabriken. [Cl. 214-1.] Apparatus for moistening or otherwise treating fiberboard sheets includes sheet-turning and feeding means.

Carter, Sidney T. Labeling machine. U. S. patent 2,940,630. Filed Dec. 5, 1955. 65 claims. Assigned to Geo. J. Meyer Mfg. Co. [Cl. 216-13.]

Christenson, Roger M., and Vogel, Henry A. Resinous coating composition comprising nitrocellulose and aldehyde modified amide polymer and metallic surface coated therewith. U. S. patent 2,940,943. Filed Feb. 25, 1957. 11 claims. Assigned to Pittsburgh Plate Glass Co. [Cl. 260-15.]

Conti, John D. Semiautomatic wrapping machine. U. S. patent 2,940,236. Filed Sept. 17, 1956. 16 claims. Assigned to American Viscose Corp. [Cl. 53-379.] A neat package is provided despite the irregular surface of the article being packaged.

Deeken, Carl L. Steering roll construction. U. S. patent 2,940,752. Filed Feb. 27, 1958. 12 claims. Assigned to Electric Eye Equipment Co. [Cl. 271-2.6.] An improved mounting is provided for a guide roll used for correcting the lateral position of a web of paper being fed through a printing press or the like.

Dott, Caspar. Apparatus for sprinkling band-like webs or foils, more particularly roofing felts. U. S. patent 2,940,422. Filed April 23, 1957. 6 claims. [Cl. 118-312.]

Dunning, Robert M. Folder lock. U. S. patent 2,940,655. Filed July 16, 1957. 6 claims. Assigned to Waldorf Paper Prods. Co. [Cl. 229-87.] A flat walletlike carton is provided with means for locking the closure flaps.

Easter, Ross A. Container. U. S. patent 2,940,654. Filed Sept. 18, 1958. 4 claims. Assigned to The Pillsbury Co. [Cl. 229-43.] An open-top carton has a plastic cover sealed thereto by means of flanges on the carton walls.

Elsas, Norman E. Method of and apparatus for starch cooking. U. S. patent 2,940,876. Filed Nov. 27, 1956. 7 claims. [Cl. 127-28.]

Fiegley, David A., Jr., nd Ray, Leonard N., Jr. Asbestos fiber treatment. U. S. patent 2,940,892. Filed Sept. 3, 1957. 23 claims. Assigned to Armstrong Cork Co. [Cl. 162-145.] The water drainage properties of the fibers are improved for papermaking purposes by adding a salt of an organic compound such as rosin acids.

Fiegley, David A., Jr., and Ray, Leonard N., Jr. Controlled precipitation of rubber onto asbestos fibers. U. S. patent 2,940,-893. Filed Dec. 23, 1957. 14 claims. Assigned to Armstrong Cork Co. [Cl. 162-155.]

Fournier, Louis P. Core shaft remover for paper unwinding apparatus. U. S. patent 2,940,681. Filed Jan. 7, 1957. 1 claim. Assigned to International Paper Co. [Cl. 242-68.]

Garwin, Leo. Method of fractionating fatty pitches. U. S. patent 2,940,965. Filed May 7, 1958. 9 claims. Assigned to Kerr-McGee Oil Inds., Inc. [Cl. 260-97.6.] The pitch may be tall oil pitch.

Graveno, John C. Container. U. S. patent Re. 24,839. Filed July 8, 1959. (Divided; original filed April 14, 1953.) 3 claims. Assigned 50% to Joseph E. Stern. [Cl. 229-17.] An improved combined opener and pouring spout is provided in a gable-top paperboard milk carton.

Gross, Frank C. Carton locking apparatus. U. S. patent 2,940,235. Filed Jan. 10, 1958. 6 claims. Assigned to Package Machinery Co. [Cl. 53-376.] The apparatus effects locking of a hinged lid carton closure by a tongue-and-slot arrangement.

Heritage, Clark C. Suction felter apparatus and method. U. S. patent 2,940,135. Filed Jan. 30, 1953. 20 claims. Assigned 50% to Weyerhauser Co., and 50% to Wood Conversion Co. [Cl. 19-156.]

Hiatt, Gordon D., and Emerson, John. Coated medicaments. U. S. patent 2,940,901. Filed Feb. 3, 1958. 5 claims. Assigned to Eastman Kodak Co. [Cl. 167-82.] Cellulose acetate diethyl amino acetate is used.

Holden, Thomas M. Paperboard chairs. U. S. patent 2,940,513. Filed Aug. 20, 1956. 3 claims. Assigned to Fleming & Sons, Inc. [Cl. 155-191.]

Hook, Robert D. H. Package for cigarettes and other articles. U. S. patent 2,940,590. Filed March 10, 1958. 7 claims. [Cl. 206-41.2.] A hinged cover construction is provided for a cigarette box.

Hultkrans, Paul B. Container for sliced food products. U. S. patent 2,940,861. Filed March 31, 1958. 6 claims. Assigned to Milprint, Inc. [Cl. 99-171.] A windowed walletlike carton without overwrap is used to pack bacon slices.

Mestre, Luis. Collating machine. U. S. patent 2,940,750. Filed Nov. 26, 1957. 47 claims. [Cl. 270-58.]

Miessler, Paul W., Sr. Container for lamp bulbs or the like. U. S. patent 2,940,653. Filed Sept. 16, 1957. 4 claims. Assigned to The Hankins Container Co. [Cl. 229-39.] The container is a single-faced sleeve of corrugated with a partition which permits insertion of two light bulbs in nesting relation.

Muller, Paul A. Method of producing endless fibre webs having irregular surfaces. U. S. patent 2,940,891. Filed Aug. 23, 1956. 5 claims. [Cl. 162-113.] A web of paper is mechanically deformed and used to make cigarette filters.

Murphy, Emmett H. Apparatus for packing containers into cases. U. S. patent 2,940,579. Filed June 17, 1958. 5 claims. Assigned to Food Machinery and Chem. Corp. [Cl. 198-21.] Tiers of containers are transferred from a multifile supply conveyor into a shipping case.

Penrod, William R., and Phelps, Richard W. Paper machinery. U. S. patent 2,940,418. Filed March 27, 1959. 12 claims. Assigned to The Black-Clawson Co. [Cl. 118-63.] Improved control of the air knife is provided in an air doctor for coating paper.

Peterson, Clarence G. Bag filling and handling means. U. S. patent 2,940,482. Filed March 2, 1956. 9 claims. [Cl. 141-95.] Cream is packed in polyethylene bags, which are subsequently packed in cartons.

Pritchard, Howard A. Sheet delivery means for rotary printing press. U. S. patent 2,940,387. Filed Aug. 21, 1958. 7 claims. Assigned to Harris-Intertype Corp. [Cl. 101-183.]

Reed, Arthur M. Apparatus for delivering and stacking blocks of sheets and the like. U. S. patent 2,940,616. Filed March 20, 1957. 5 claims. Assigned to Charles R. Stevens, Inc. [Cl. 214-6.] Blocks of paper sheets are delivered from a trimming machine and are moved to a station at which they are stacked.

Reed, Arthur M. Apparatus for removing blocks of sheets and the like from stacks and feeding them forwardly. U. S. patent 2,940,617. Filed March 20, 1957. 6 claims. Assigned to Charles R. Stevens, Inc. [Cl. 214-8.5.] Blocks of paper sheets are removed from a stack and forwarded to a trimming machine.

Smith, Frederick A., and Welch, Thomas H. Silicone-coated fibrous products and process therefor. U. S. patent 2,940,875. Filed June 19, 1956. 7 claims. Assigned to Union Carbide Corp. [Cl. 117-161.] The release coatings provided don't reduce adhesive properties of materials brought into contact with the coatings.

Sprague, Robert H., and Friello, Dominick R. Heat sensitive copy sheet. U. S. patent 2,940,866. Filed April 10, 1957. 18 claims. Assigned to Sperry Rand Corp. [Cl. 117-36.]

Stoothoff, Stanley T. Apparatus for mounting films and other inserts in cards. U. S. patent 2,940,754. Filed March 29, 1957. 5 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 271-36.]

White, Deane R. Adhesive tape. U. S. patent 2,940,884. Filed March 30, 1956. 2 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 154-53.5.] A tape for cinema film patching uses a paper liner and paper patches to block out certain adhesive areas.

June 21, 1960

Abramowitz, Eddie. Packaging device for neckties and the like foldable articles. U. S. patent 2,941,703. Filed Jan. 24, 1958. 1 claim. [Cl. 223-87.] The device is formed of paperboard.

Akkeron, Ludwig F. Heat resistant decalcomania transfer and method of making and using the same. U. S. patent 2,941,-916. Filed Oct. 19, 1956. 17 claims. Assigned to The Meyercord Co. [Cl. 154-95.]

Allen, Robert T. Coin counter and wrapper. U. S. patent 2,941,342. Filed Oct. 7, 1958. 1 claim. [Cl. 53-154.]

Balassa, Leslie L. Method for increasing the pigment content of presscakes. U. S. patent 2,941,896. Filed July 23 1958. 8 claims. Assigned to J. R. Geigy A.-G. [Cl. 106-309.] Methylcellulose is used.

Biek, George. Window envelope and addressed filler sheet assembly. U. S. patent 2,941,711. Filed May 10, 1957. 1 claim. [Cl. 229-73.]

Cassady, Robert T. Method of and apparatus for regulating

corrugating machines (variable heat double facer). U. S. patent 2,941,573. Filed March 28, 1958. 15 claims. [Cl. 154-32.]

Clinton, Otto M. Dough cutting and can filling machine. U. S. patent 2,941,341. Filed Feb. 17, 1958. 13 claims. Assigned to General Mills, Inc. [Cl. 53-123.] Biscuit dough wafers are cut and loaded into a container comprising a lined cylindrical paper tube closed at the ends.

Crane, Harold S., and Comstock, Alfred E. Molded pulp container. U. S. patent 2,941,708. Filed April 16, 1958. 3 claims. Assigned to Diamond Natl. Corp. [Cl. 229-2.5.] A molded pulp blank is designed to be set up to form an insulating container for products such as ice cream.

Crawford, Charles P. Filter for cigarettes. U. S. patent 2,941,533. Filed Oct. 10, 1957. 1 claim. [Cl. 131-10.] The filter is formed of tissue paper.

Densen, Paul, and Roberts, Lawrence H. Edge aligning means for travelling combining webs. U. S. patent 2,941,572. Filed May 6, 1957. 1 claim. Assigned to Eastern Corrugated Container Corp. [Cl. 154-31.] This apparatus is for use in a corrugating machine.

Ford, James G. Electrical coil. U. S. patent 2,942,217. Filed Aug. 30, 1957. 5 claims. Assigned to Westinghouse Elec. Corp. [Cl. 336-205.] The insulation includes kraft paper coated with an adhesive layer carrying tissue paper or linters.

Fusco, James J. Fourdrinier wire stretch. U. S. patent 2,941,593. Filed July 23, 1958. 6 claims. Assigned to The Sandy Hill Iron & Brass Works. [Cl. 162-273.] Improved wire-tensioning means are provided on a fourdrinier machine.

Harker, Charles B. Apparatus for handling flexible walled bags. U. S. patent 2,941,676. Filed Feb. 17, 1954. 7 claims. Assigned to Riegel Paper Corp. [Cl. 214-7.] The apparatus moves filled bags from edge-to-edge to face-to-face relation.

Harless, Charles A. Sheet cutting and folding machine. U. S. patent 2,941,798. Filed Dec. 18, 1958. 11 claims. Assigned to Hess and Barker. [Cl. 270-72.]

Huber, Richard, and Zottmann, Otto. Primary galvanic cell. U. S. patent 2,942,057. Filed June 27, 1958. 5 claims. Assigned to Pertrix-Union G.m.b.H. [Cl. 136-145.] Aluminum carboxymethylcellulose and kraft paper are used.

McAdow, Walter R. Metallized coating compositions. U. S. patent 2,941,894. Filed March 16, 1955. 7 claims. Assigned to American-Marietta Co. [Cl. 106-193.] Cellulose nitrate is used.

McConnaughay, Kenneth E. Bituminous emulsion. U. S. patent 2,941,893. Filed Dec. 22, 1955. 8 claims. [Cl. 106-176.] Hydroxypropylmethylcellulose and crude tall oil are used in compounding a road-paving composition.

Minkow, Julius M. Pressure applying machine for use in paper box making. U. S. patent 2,941,452. Filed May 26, 1958. 1 claim. Assigned to City Paper Box Co., Ltd. [Cl. 93-36.3.] The end panels of boxes are pressed together while the adhesive sets.

Newman, Douglas A., and Schlotzhauer, Allan T. Planographic printing plates. U. S. patent 2,941,466. Filed Aug. 24, 1956. 3 claims. Assigned to Columbia Ribbon & Carbon Mfg. Co., Inc. [Cl. 101-149.2.] The paper-base plate is prevented from becoming excessively ink sensitive.

Osberg, Stanley C. Means for and manner of packaging valves and similar products. U. S. patent 2,941,662. Filed May 22, 1958. 2 claims. Assigned to National Lock Co. [Cl. 206-65.] The valves are packed between two pads made of several plies of corrugated paper.

Palmer, Charles E. Plastic container secured to card. U. S. patent 2,941,664. Filed April 7, 1959. 3 claims. [Cl. 206-80.]

Plevyak, Chester E. Shipping container. U. S. patent 2,941,709. Filed May 6, 1957. 4 claims. Assigned to Westinghouse Elec. Corp. [Cl. 229-14.] A carton and interior packing member are provided for packing a fragile article such as a radio receiver.

Potts, William M., Price, Clegg E., Darholt, Jerome O., and Dans, Bernard D. Carton-forming and closing means and method. U. S. patent 2,941,340. Filed April 19, 1957. 52 claims. Assigned to Dacam Corp. [Cl. 53-34.] The carton is for packing men's hose or the like.

Rogers, Howard H. Multiple opening press. U. S. patent 2,941,249. Filed May 29, 1958. 11 claims. Assigned to Williams-White & Co. [Cl. 18-17.] Improved means are provided for opening and closing a multiple-opening hot-press for making hardboard, etc.

Rosenbacher, Saul E. Paper board display stand. U. S. patent 2,941,773. Filed Feb. 6, 1957. 4 claims. Assigned to Max Stern's Sons Co. [Cl. 248-174.]

Rosenblad, Curt F. Multiple evaporation methods. U. S. patent 2,941,590. Filed March 14, 1955. 4 claims. [Cl. 159-47.] The evaporator, for spent pulping liquors, is designed to reduce the effects of corrosion produced by corrosive noncondensable gases.

Salwasser, Melvin. Case packing machine and method. U. S. patent 2,941,339. Filed Feb. 10, 1955. 8 claims. [Cl. 53-26.] Cartons or bags are arranged into a group and the group inserted into a shipping container.

Simon, Edward M., Jr. Spinning of viscose. U. S. patent 2,941,892. Filed Jan. 31, 1955. 5 claims. Assigned to Atlas Powder Co. [Cl. 106-165.] A high-tenacity rayon fiber is produced from a viscose to which has been added a polyoxyethylene ether of a polyhydric alcohol.

Watkins, Spencer H. Sizing of paper. U. S. patent 2,941,919. Filed Jan. 31, 1957. 5 claims. Assigned to Hercules Powder Co. [Cl. 162-180.] The efficiency of tall oil rosin size is improved by reaction with formaldehyde.

Wells, Roger. Drying apparatus. U. S. patent 2,941,655. Filed June 7, 1957. 7 claims. Assigned to Diamond Natl. Corp. [Cl. 198-131.] A drier for molded pulp articles is designed to prevent warping of the articles.

Willis, Claude E. F. Web supply mechanism. U. S. patent 2,941,742. Filed July 13, 1956. 3 claims. Assigned to R. W. Crabtree & Sons Ltd. [Cl. 242-58.] Means for effecting changeover from an old to a new web supply roll being fed to a printing press is provided with means for controlling web tension during the transfer.

Zimmerli, Kurt. Removable roll means for calender. U. S. patent 2,941,465. Filed March 25, 1959. 5 claims. Assigned to B. F. Perkins & Sons, Inc. [Cl. 100-155.]

June 28, 1960

Atkinson, William G. Apparatus for setting up corner lock cartons. U. S. patent 2,942,533. Filed Nov. 19, 1956. 2 claims. Assigned to Somerville Ltd. [Cl. 93-51.]

Baumgartner, John R. Carton blank feeding mechanism. U. S. patent 2,942,765. Filed May 24, 1956. 6 claims. Assigned to Mercury Eng. Corp. [Cl. 225-94.] Multiple blanks formed by a blanking press are separated as they are delivered.

Beachler, Edward D. Multi-ply sheet former. U. S. patent 2,942,661. Filed Dec. 18, 1956. 2 claims. Assigned to Beloit Iron Works. [Cl. 162-304.] A multi-ply web is formed on a fourdrinier wire, with each ply being dewatered before the next is laid down.

Beerend, Ray F. Method for packaging sausage patties. U. S. patent 2,942,987. Filed April 22, 1957. (Divided; original filed Jan. 20, 1955.) 3 claims. [Cl. 99-174.] A number of sausage patties are formed and deposited onto a flat carton blank, which is then wrapped around them.

Boddy, Charles A. Rotary cutter for paper board box machines. U. S. patent 2,942,534. Filed June 6, 1955. 2 claims. Assigned to St. Regis Paper Co. [Cl. 93-58.2.] The cutter trims the blank flaps to a tapered configuration.

Bodendoerfer, Raymond E. Blank wrapping mechanism for frustoconical cup making machines. U. S. patent 2,942,530. Filed Dec. 24, 1958. 7 claims. Assigned to Paper Machinery Corp. [Cl. 93-36.1.]

Collura, Peter C., and Hurley, Robert M. Paperboard carrier with handle. U. S. patent 2,942,756. Filed April 21, 1958. 6 claims. Assigned to Container Corp. of America. [Cl. 220-113.] A carrier carton is provided for two bottles or cans.

Ferris, Seymour W. Wax coating compositions. U. S. patent 2,942,766. Filed Feb. 27, 1959. 17 claims. Assigned to Sun Oil Co. [Cl. 229-3.1.] A composition of wax and fine fibers is used to coat cartons.

Fowlie, Wallace R., Tregay, John L., and DuBois, Edgar H. Sheet feed mechanism for duplicators. U. S. patent 2,942,877. Filed Oct. 3, 1956. 10 claims. Assigned to A. B. Dick Co. [Cl. 271-31.]

Frankenfield, Andrew D. Paper doll cut-outs. U. S. patent 2,942,271. Filed Oct. 29, 1956. 1 claim. [Cl. 2-74.]

Gale, George N. Display device. U. S. patent 2,942,368. Filed Nov. 3, 1958. 5 claims. [Cl. 40-158.] A device for displaying a magazine tear sheet or the like comprises a laminated display board supported by an easel stand.

Goodwillie, John E. Cylinder type paper making machine. U. S. patent 2,942,662. Filed March 6, 1956. 9 claims. Assigned to Beloit Iron Works. [Cl. 162-317.]

Hogstrom, Nils H. Carton dispenser with means to withdraw the lowermost carton. U. S. patent 2,942,758. Filed March 11, 1955. 3 claims. Assigned to The Ful-Vue-Pak Co. [Cl. 221-222.] Cartons are fed to a filling machine from a supply stack of nested cartons.

Kondrat, Walter. Carton holder. U. S. patent 2,942,828. Filed Nov. 14, 1958. 2 claims. [Cl. 248-145.6.] A wire rod device is provided for use as a holder and handle element for a milk carton during the use thereof.

Kuchenbecker, Morris W. Receptacle. U. S. patent 2,942,769. Filed Jan. 13, 1958. 2 claims. Assigned to American Can Co. [Cl. 229-31.] Improved locking means are provided for holding a flat open-top box in erected condition.

Lerner, Philip. Method of producing a partial vacuum package. U. S. patent 2,942,390. Filed Dec. 15, 1958. 7 claims. [Cl. 53-22.] A stack of meat slices or the like is sup-

ported on a paperboard card and a transparent film is sealed around them.

Loeser, Donald B., and Bodendoerfer, Raymond E. Bottom expander for paper cups. U. S. patent 2,942,531. Filed July 20, 1959. 6 claims. Assigned to Paper Machinery Corp. [Cl. 93-36.5.]

McCall, Richard J. Box. U. S. patent 2,942,768. Filed Dec. 29, 1958. 2 claims. Assigned to Mack-Chicago Corp. [Cl. 229-16.] A corrugated carton of hinged tuck-flap lid construction is designed to save stock and to improve carton strength.

McIlvain, John G., and Wolfer, George J. Series drive for web fed rotary printing machine. U. S. patent 2,942,543. Filed Jan. 25, 1957. 2 claims. Assigned to Downingtown Paper Box Co. [Cl. 101-181.]

Morrison, Willard L. Method of shipping frozen food. U. S. patent 2,942,428. Filed Oct. 23, 1957. 4 claims. Assigned to Liquefreeze Co., Inc. [Cl. 62-60.] The system described involves packing the food in cartons.

Ouellette, Clarence P. Tear tape applying mechanism for a wrapping machine. U. S. patent 2,942,528. Filed May 6, 1957. 17 claims. Assigned to Crompton & Knowles Corp. [Cl. 93-1.] The machine provided cuts tongues in a sheet of wrapping material, then applies strips of tear tape across the tongues.

Pearce, Lewis C. Apparatus for forming and affixing a divider in a box. U. S. patent 2,942,532. Filed Aug. 9, 1956. 22 claims. Assigned to American Greetings Corp. [Cl. 93-37.]

Piazze, Thomas E. Bag making machine and method. U. S. patent 2,942,529. Filed May 8, 1957. 11 claims. Assigned to Continental Can Co., Inc. [Cl. 93-12.]

Pitner, Lloyd E. Method of producing and binding display books. U. S. patent 2,942,283. Filed Dec. 8, 1952. 3 claims. [Cl. 11-1.] The display book has pages which open out to form a three-dimensional scene or display.

Shapery, Arthur W., and Shapery, Lillian. Self-totaling coin accounting and banking aid. U. S. patent 2,942,723. Filed June 11, 1957. 3 claims. [Cl. 206-.84.] A paper device having coin-retaining pockets imprinted with a cumulative total value is provided for use in making bank deposits.

Spigelman, Irvin G. Article support. U. S. patent 2,942,771. Filed Dec. 3, 1957. 8 claims. Assigned to Chicago Printed String Co. [Cl. 229-52.] A large carton is provided with a top construction which includes a strap handle.

Sweet, Howard A. Alphabetic windowed merchandising displaying folder. U. S. patent 2,942,727. Filed Sept. 4, 1957. 1 claim. [Cl. 206-56.] Pills are packed in a transparent packet retained within a matchbook-like folder having a window in the front panel.

Weiss, Arthur J. Folding paperboard carton. U. S. patent 2,942,767. Filed Dec. 5, 1956. 6 claims. Assigned to Continental Can Co., Inc. [Cl. 229-16.] A carton of known type is designed so that its size can be increased while still permitting it to be glued up on existing machines.

Yingling, Victor N., and Seel, Howard J. Sheet delivery slowdown. U. S. patent 2,942, 878. Filed Oct. 4, 1956. 26 claims. Assigned to Harris-Intertype Corp. [Cl. 271-79.]

The following patents were received later than those of the same issue date and have accumulated during the past quarter.

June 16, 1959

Bailey, Edward A., Bradicich, John B., and Crathern, Charles, F. H. Paper box machine. U. S. patent 2,890,630. Filed March 28, 1956. 21 claims. Assigned to Food Machinery and Chemical Corp. [Cl. 93-41.] Means are provided to cut out the corners of box blanks and fold and erect the blanks to form boxes.

Oct. 13, 1959

Tolkmith, Henry, and Britton, Edgar C. *O*-aryl *O*-methyl phosphoroamidothioates. U. S. patent 2,908,706. Filed March 5, 1956. 3 claims. Assigned to Dow Chem. Co. [Cl. 260-461.] These are preservatives for paper.

Nov. 10, 1959

Groves, Kenneth D. Drilling fluids and method of preventing loss thereof from well holes. U. S. patent 2,912,380. Filed July 17, 1953. 7 claims. Assigned to American Viscose Corp. [Cl. 252-8.5.] Cellulose esters and wood fibers are among the additives used.

Hold, Peter. Electrically heated roll for calenders or the like. U. S. patent 2,912,556. Filed May 2, 1958. 11 claims. Assigned to Farrel-Birmingham Co., Inc. [Cl. 219-19.]

Kosche, Horst. Method of preparing esters of cellulose ether carboxylic acids. U. S. patent 2,912,430. Filed Dec. 6, 1955. 6 claims. Assigned to Henkel & Cie., G.m.b.H. [Cl. 260-226.]

Liao, Tseng W., and Nichols, Frank S. Electrical insulating structure and method of making the same. U. S. patent 2,-912,382. Filed Sept. 5, 1957. 11 claims. Assigned to General Electric Co. [Cl. 252-63.2.] Paper or board is impregnated with an electronegative fluorogas, then with a hardenable insulating resin.

Stilbert, Elmer K., Jr., Cummings, Ira J., and Clock, Gerald E. Intumescent coating composition and articles coated therewith. U. S. patent 2,912,392. Filed June 27, 1956. 10 claims. Assigned to The Dow Chemical Co. [Cl. 260-17.4.] Wallboard is provided with a wash-resistant intumescent fire-retardant coating.

Stilbert, Elmer K., Jr., Cummings, Ira J., and Clock, Gerald E. Intumescent coating composition and articles coated therewith. U. S. patent 2,912,393. Filed Dec. 24, 1958. 9 claims. Assigned to The Dow Chemical Co. [Cl. 260-17.4.] This is similar to U. S. patent 2,912,392 (Nov. 10, 1959).

Stilbert, Elmer K., Jr., Cummings, Ira J., and Clock, Gerald E. Intumescent coating composition and articles coated therewith. U. S. patent 2,912,394. Filed Dec. 24, 1958. 10 claims. Assigned to The Dow Chemical Co. [Cl. 260-17.4.] This is similar to U. S. patent 2,912,392 (Nov. 10, 1959).

Taverna, Arthur R. Addition agent for cadmium plating solution. U. S. patent 2,912,370. Filed Oct. 7, 1957. 18 claims. Assigned to Allied Research Prods., Inc. [Cl. 204-50.] Hydroxyethylcellulose is used as the additive.

Dec. 8, 1959

Vierk, Ernest R., and Karr, Theodore J. Lubricating compositions. U. S. patent 2,916,449. Filed July 22, 1957. 12 claims. Assigned to Sinclair Refining Co. [Cl. 252-32.7.] This is a paper machine lubricant.

Dec. 15, 1959

Apel, Alfons, and Rossler, Georg. Preparation of stable polyol solutions and the resulting product. U. S. patent 2,-917,390. Filed Dec. 12, 1957. 7 claims. Assigned to Udic Société Anonyme. [Cl. 99-142.] The solutions are prepared from liquors obtained in the saccharification of cellulose materials.

Peterson, Norman R., and Cummings, Ira J. Latex-base intumescent coating compositions containing solid plasticizers. U. S. patent 2,917,476. Filed April 2, 1956. 2 claims. Assigned to Dow Chemical Co. [Cl. 260-17.4.] The coating is for wallboard.

Dec. 29, 1959

Etheridge, Oliver R. Apparatus for pasting or cooking starch. U. S. patent 2,919,214. Filed Jan. 31, 1958. 9 claims. Assigned to A. E. Staley Mfg. Co. [Cl. 127-28.]

Jan. 12, 1960

Allen, Edward M. Method of preparing a finely-divided alumina-silica pigment. U. S. patent 2,920,974. Filed Feb. 15, 1957. 10 claims. Assigned to Columbia-Southern Chem. Corp. [Cl. 106-288.] The pigment is a paper-opacifying agent.

Jan. 19, 1960

Stannett, Vivian T., and Shibel, Frederick C. Para-urazine-formaldehyde resin. U. S. patent 2,921,924. Filed Feb. 20, 1958. 5 claims. Assigned to W. R. Grace & Co. [Cl. 260-67.6.] The resin is of use in improving the wet and dry strength of paper and in other adhesive applications.

Jan. 26, 1960

Boettner, Fred E. N-alkyl-N-sorbitylureas. U. S. patent 2,922,784. Filed Feb. 27, 1958. 5 claims. Assigned to Rohm & Haas Co. [Cl. 260-211.] These compounds are of use in imparting rewetting properties to wet-strength papers.

Tolkmith, Henry. Method for the manufacture of phosphorodichloridothioates. U. S. patent 2,922,814. Filed Sept. 3, 1957. 4 claims. Assigned to Dow Chem. Co. [Cl. 260-461.] The product is of use as a preservative for paper.

Feb. 2, 1960

Braunlich, Richard H. Gas solid contact. U. S. patent 2,923,378. Filed April 5, 1955. 5 claims. Assigned to American Viscose Corp. [Cl. 183-114.2.] Filaments of viscose containing a chemical reagent are prepared for use in various chemical processes.

Fawley, Harry, Golben, Michael, and Dubé, David J. Xanthate dissolver. U. S. patent 2,923,604. Filed Feb. 18, 1957. (Divided; original filed Aug. 13, 1954.) 4 claims. Assigned to American Viscose Corp. [Cl. 23-286.] The apparatus provided effects the dissolution of difficulty soluble xanthate crumbs without comminuting insoluble particles.

Klager, Karl Nitroisocyanates. U. S. patent 2,923,726. Filed Jan. 21, 1954. 8 claims. Assigned to Aerojet-General Corp. [Cl. 260-453.] These compounds are of use as water-proofing agents for paper.

Szumski, Stephen A., and Petty, Milton A. Composition of matter for the control of foam. U. S. patent 2,923,688. Filed Jan. 29, 1958. 11 claims. Assigned to American Cyanamid Co. [Cl. 252-321.] A papermaking foam inhibitor comprises a glyceride oil to which has been added a rice oil sludge.

Feb. 23, 1960

Costa, Joseph L., and Morse, Reginald A. Filter medium. U. S. patent 2,925,879. Filed Nov. 6, 1944. 1 claim. Assigned to U. S. Secretary of War. [Cl. 183-4.] Rayon filaments for gas filters are spun from viscose containing activated charcoal.

Sakornbut, Songe S. Impregnating composition. U. S. patent 2,926,096. Filed April 27, 1955. 14 claims. Assigned to Monsanto Chem. Co. [Cl. 106-15.] The composition, for rendering paper resistant to flame, fungi, and insects, includes pentachlorophenol and a phosphoric acid ester.

March 8, 1960

Heyer, Don. Method of and apparatus for forming sealed packages. U. S. patent 2,927,409. Filed Sept. 24, 1956. 50 claims. [Cl. 53-22.] A skin pack is formed.

Paton, Joseph H., and Vander Pyl, Chester A., Jr. Apparatus for curing the end caps of filter cartridges. U. S. patent 2,-927,782. Filed April 5, 1957. 2 claims. Assigned to Fram Corp. [Cl. 263-7.] The plastic end caps of pleated paper filter cartridges are cured.

Revoir, Harold J. Pressure-sensitive adhesive tape. U. S. patent 2,927,868. Filed Jan. 15, 1958. 1 claim. Assigned to Minnesota Mining & Mfg. Co. [Cl. 117-76.] An anchor coating is provided for securing the pressure-sensitive adhesive layer to a backing of cellulose acetate film.

March 15, 1960

Chamberlin, George E., and Knutson, Russell G. Process for the manufacture of primer coated fiber board. U. S. patent 2,928,129. Filed May 13, 1957. 10 claims. Assigned to Minnesota and Ontario Paper Co. [Cl. 18-47.5.]

Eberl, James J., Stonehill, Albert A., and Masci, Joseph N. Sterilization of gums. U. S. patent 2,928,717. Filed March 27, 1957. 16 claims. Assigned to Johnson & Johnson. [Cl. 21-58.] Sodium carboxymethylcellulose and other gums are prepared in the form of a sterile aqueous dispersion of use in pharmaceutical and like fields.

Lonngren, Harald E. Sulfate liquor recovery process. U. S. patent 2,928,184. Filed May 24, 1956. 7 claims. Assigned to Esso Research and Engineering Co. [Cl. 34-10.]

Touey, George P. Fibrous tobacco smoke filter. U. S. patent 2,928,399. Filed May 27, 1954. 6 claims. Assigned to Eastman Kodak Co. [Cl. 131-208.] This is similar to U. S. patent 2,928,400 (March 15, 1960).

Touey, George P. Fibrous tobacco smoke filters. U. S. patent 2,928,400. Filed June 24, 1954. 8 claims. Assigned to Eastman Kodak Co. [Cl. 131-208.] The filter comprises cellulose acetate filaments and gum particles, with a paper wrapper.

March 22, 1960

Lienhard, Gustav O. Paper containing fabric. U. S. patent 2,929,414. Filed Aug. 18, 1955. 4 claims. Assigned to Chicopee Mfg. Co. [Cl. 139-420.] A fabric is woven of paper and saran strands.

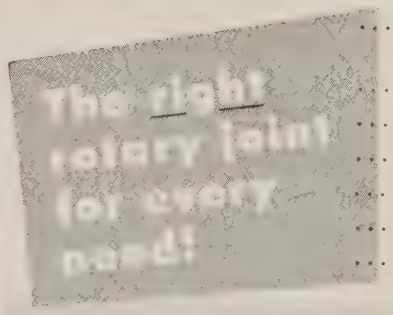
March 29, 1960

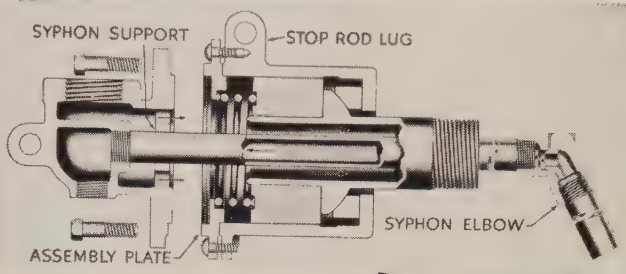
Frind, Horst. Process of producing cuprammonium cellulose articles. U. S. patent 2,930,671. Filed May 7, 1957. 15 claims. Assigned to J. P. Bemberg A.G. [Cl. 18-54.] The spinning solution is coagulated, the coagulated material is stretched, and then the material is regenerated.

Perkins, Glenn H. Planographic printing plate provided with a methylolated polyacrylamide coating and process of making. U. S. patent 2,930,317. Filed Dec. 19, 1956. 6 claims. Assigned to Oxford Paper Co. [Cl. 101-149.2.] This is a paper-base offset printing plate.

Pettee, Herbert M., Sabee, Reinhardt N. Device for feeding articles into cartons. U. S. patent 2,930,172. Filed March 17, 1955. 13 claims. Assigned to The Procter & Gamble Co. [Cl. 53-124.] Compressible articles are loaded into cartons having a smaller dimension than that of the uncompressed articles.

Stuckey, James M. Method of separating hydrocarbons. U. S. patent 2,930,754. Filed July 16, 1954. 9 claims. Assigned to Pan American Refining Corp. [Cl. 210-23.] Cellulose esters are used to form a nonporous membrane for use in separating hydrocarbons.





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RECENT BOOKS

Elements of Ion Exchange. By Robert Kunin, Rohm & Haas Co. New York, 1960. Reinhold Publishing Co. Pyroxylin, 5 × 7½, 164 pages. $5.75.

The author wrote this book for the benefit of the non-expert who might have only a slight background of basic chemistry. It deals with the nature of ion-exchange materials, testing and evaluation, applications, water conditioning, and ion-exchange calculations.

Polyester Resins. By John B. Lawrence, Glidden Co. New York, 1960. Reinhold Publishing Co. 5 × 7½, 251 pages. $5.75.

The fifteenth volume in the Reinhold Plastics Applica-

46th

Annual Meeting

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Feb. 19–23, 1961

tion Series deals with the unsaturated polyester resins, widely employed in reinforced plastics. The book presents a review of polyester resins from the standpoint of chemistry, curing, and diversified applications. Among the subjects covered are general properties, formulating for special properties, catalysts and curing, molding, laminating, and coating.

Metallizing of Plastics. By Harold Narcus, Electrochemical Industries. New York, 1960. Reinhold Publishing Co. 5 × 7½, 208 pages. $5.50.

The sixteenth volume in the Reinhold Plastics Application Series. A semitechnical book addressed to engineers, designers, students, and practical operators. Much emphasis is given the function of metallizing for decorative purposes. Consideration is given to deposition of metallic coatings by chemical reduction, vacuum metallizing, the cathode-sputtering process, the silver-spray method, and electrodeposition.

Runnerless Molding. By Ernest P. Moslo, Moslo Machinery Co. New York, 1960. Reinhold. 5 × 7½, 162 pages. $4.95.

A survey of the theory, design applications, and economics of runnerless molding. It describes in detail the various techniques of injection molding accomplished without the removal of a sprue and runner system on each injection molding shot.

Plant Pathology. Vols. 2 and 3. Edited by J. G. Horsfall and A. E. Dimond. New York, 1960. Academic Press. Cloth, 6 × 9, 715 and 675 pages. $22 each.

Volume I of Plant Pathology relating to the diseased plant was reviewed in the May, 1960 issue of *Tappi*. Volume 2 relates to the pathogen and Volume 3 deals with the diseased population epidemics and controls.

The editors are members of the staff of the Connecticut Agricultural Experiment Station at New Haven, Conn. In Volume 1 the diseased plant, and what disease is, was discussed. In Volume 2 is discussed the antecedants of disease, how disease originates and what causes it. The pathogen is the irritant that keeps a disease going. Among the subjects covered are the nature, origin, and evolution of parasitism, multiplication of viruses, reproduction of bacteria, actinomycetes and fungi; spore germination and fungicidal chemistry.

Volume 3 deals with the populations of plants in relation to infection and to control. Just as a human population presents problems in public health medicine, so in plant pathology populations of inoculum or of plants exhibit characteristics that are not apparent when attention is focused on the individual plant only. Disease of plants is spread by water, crop residues, insects, air seeds, and man. Among the subjects covered are analysis of epidemics, forecasting epidemics, quarantines, soil treatment, and problems of breeding.

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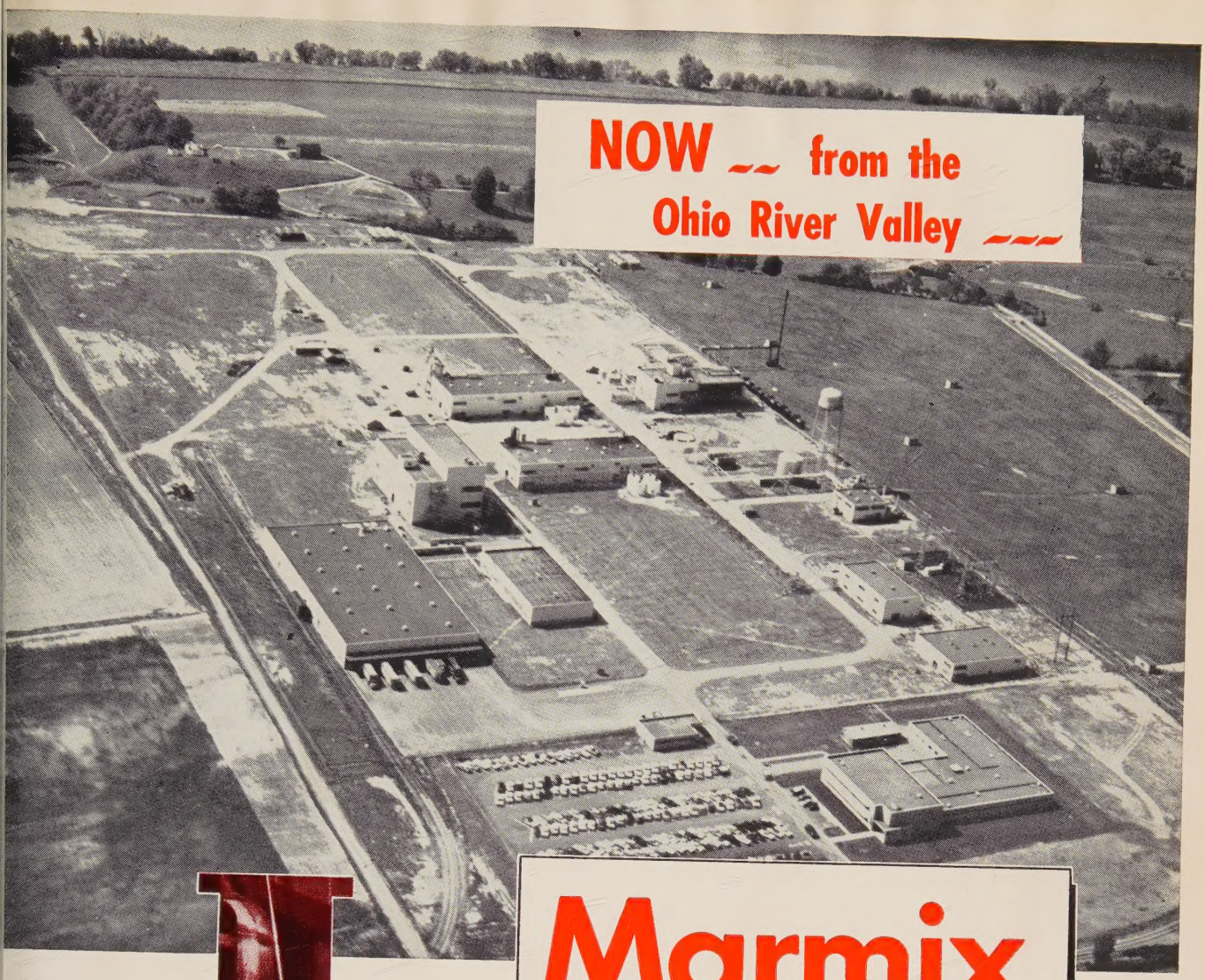

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Here, to meet your needs for resin and rubber latices, is Marbon Chemical's new multi-million dollar research and production facility on the Ohio River. In every way—plant facilities, equipment and personnel—you'll find Marbon the truly modern source for your requirements. Let us prove it—write today.

MARBON CHEMICAL DIVISION **BORG-WARNER**
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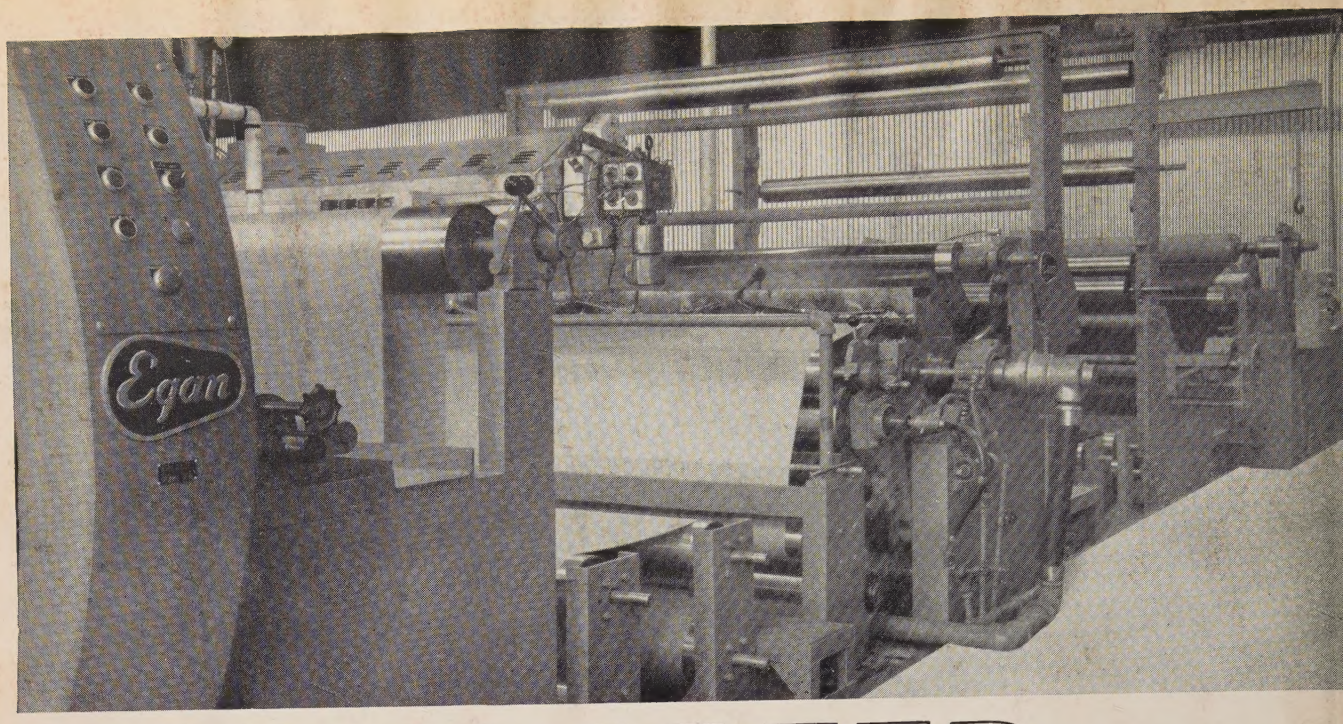


FOR HIGH-SPEED POLYETHYLENE COATING OF WIDE PAPER

CONTINUOUS OPERATION AT 1,000 FPM

When the converting operation calls for polyethylene coating of wide-web kraft and other papers, no production unit can surpass an Egan Extrusion Coater!

The coater illustrated above includes a flying-splice unwind stand, direct electric heat extruder, die, laminator, and single drum surface winder. The combination is capable of continuous operation at 1,000 fpm.

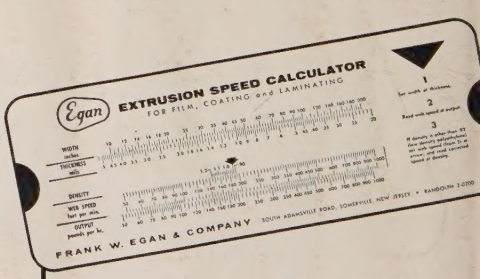
Open construction of the laminating unit permits maximum access and visibility for the operators. The laminator also has controlled stripping tension, and includes *patented* horizontal and vertical adjustments of the laminating nip which are essential for ma mum adhesion control.

The cooling roll is of a unique *patented* desig This double spiral roll provides for highly efficie cooling and extremely uniform temperatures acr the roll. Use of the double spiral permits wa to enter simultaneously from both ends of the r and exit at opposite ends from the point of ent The temperature across the entire face of t roll during operation has a differential of no m than 2°F.

Egan production units are available in widths 120″.

WORLD'S LEADING MANUFACTURER OF EXTRUSION COATER

WRITE for this handy Egan Extrusion Speed Calculator which quickly determines any extrusion capacity required for a specific web speed, width, and coating thickness.



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Egan **FRANK W. EGAN & COMPANY**
SOMERVILLE, NEW JERSEY

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